Response Cost Modeling
For Washington State Oil Spill Scenarios

EXECUTIVE SUMMARY

PRELIMINARY DRAFT

Prepared for

Washington Department of Ecology
Spills Program
P.O. Box 47600
Olympia, WA 98504-7600

Prepared by

Dagmar Schmidt Etkin, PhD
Environmental Research Consulting
41 Croft Lane
Cortlandt Manor, NY 10567-1160 USA

Washington Department of Ecology Contract No. C040018

30 June 2004

RESPONSE COST MODELING
FOR WASHINGTON STATE OIL SPILL SCENARIOS
EXECUTIVE SUMMARY

TABLE OF CONTENTS

List of Figures and Tables ………………………………………………………... 2
Overview of Oil Spill Response Costs …………………………………………. 3
Washington Oil Spill Scenarios Modeled ……………………………………... 5
- **Response Strategies ………………………………………………………. 8**
- **Response Capability ……………………………………………………… 8**
- **Available Mechanical Response Equipment ………………………………. 13**
- **Mechanical Response Equipment Effectiveness …………………………… 13**
- **Booming ………………………………………………………………… 13**
- **Canadian and Oregonian Response Levels ………………………………... 14**
- ***In-Situ* Burning Operations ……………………………………………… 15**
- **Dispersant Operations …………………………………………………… 16**

Assumptions for Modeling of Oil Spill Response Costs ……………………… 19
Oil Spill Response Cost Modeling Results …………………………………… 22
- **San Juan Islands Scenarios ……………………………………………… 23**
- **Inner Straits Scenarios …………………………………………………… 26**
- **Strait of Juan de Fuca Scenarios ………………………………………… 29**
- **Outer Pacific Coast Scenarios …………………………………………… 37**
- **Columbia River Scenarios ……………………………………………….. 41**

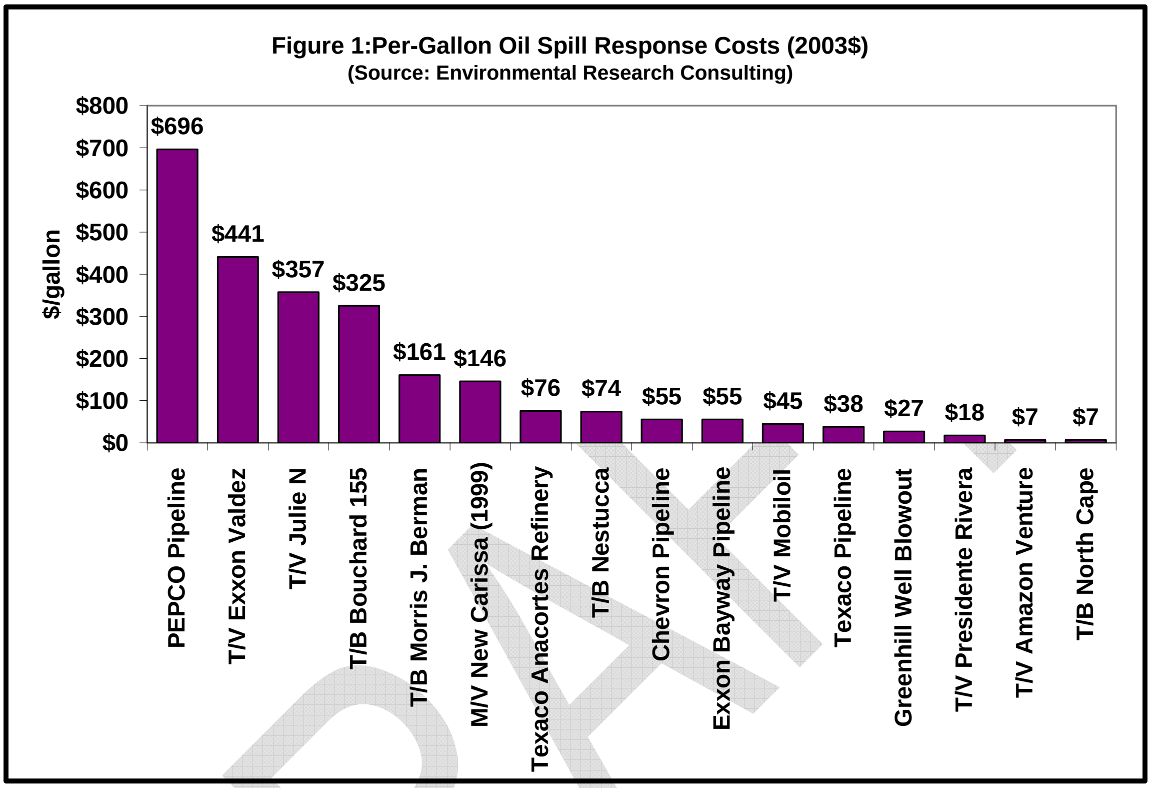
Comparison of Response Capabilities ………………………………………… 45
Comparison of Response Capabilities and Response Methods ……………… 46
Summary and Conclusions …………………………………………………... 51
References ……………………………………………………………………….. 52

LIST OF FIGURES AND TABLES

Figure 1: Per-Gallon Oil Spill Response Costs ………………………………………………. 2
Table 1: Washington Oil Spill Scenarios ……………………………………………......... 5
Table 2: Response Strategy Components for Modeled Response Types …………………… 8
Table 3: Mechanical Response Capabilities: Outer Coast 65,000 bbl ANS Crude ………... 9
Table 4: Mechanical Response Capabilities: Str Juan de Fuca 25,000 bbl Bunker C ……. 9
Table 5: Mechanical Response Capabilities: Str Juan de Fuca 65,000 bbl Diesel ………… 9
Table 6: Mechanical Response Capabilities: Str Juan de Fuca 65,000 bbl ANS Crude ….. 10
Table 7: Mechanical Response Capabilities: San Juan Islands 65,000 bbl ANS Crude…… 10
Table 8: Mechanical Response Capabilities: Inner Straits 65,000 bbl ANS Crude …........ 10
Table 9: Mechanical Response Capabilities: Columbia River 25,000 bbl Bunker C …….. 11
Figure 2: Comparative Response Capabilities: Booms …………………………………... 11
Figure 3: Comparative Response Capabilities: Recovery ……………………………….. 12
Figure 4: Comparative Response Capabilities: Storage …………………………………. 12
Figure 5: Location of Protective Booms ………………………………………………… 12
Figure 6: Areas of Assumed *In-Situ* Burning Application ……………………………......... 14
Table 10: Schedule of Dispersant Applications ………………………………………… 15
Figure 7: Areas Assumed for Dispersant Operations ……………………………………. 16
Table 11: Influence of Oil Properties on Oil Impact in Environment ……………………… 21
Table 12: Shoreline Cleanup Cost Factors ……………………………………………... 21
Table 13: Modeled Oil Spill Response Costs (w/o Shore/Disposal): San Juan Islands …… 23
Table 14: Estimated Total Response Costs: San Juan Islands …………………………… 24
Table 15: Shoreline Impact and Bbl Oil Removed: San Juan Islands …………………….. 25
Table 16: Modeled Oil Spill Response Costs (w/o Shore/Disposal): Inner Straits…… …… 26
Table 17: Estimated Total Response Costs: Inner Straits ……………………………….. 27
Table 18: Shoreline Impact and Bbl Oil Removed: Inner Straits …...…………………….. 28
Table 19: Modeled Oil Spill Response Costs (w/o Shore/Disposal): Str Juan de Fuca …… 29
Table 20: Estimated Total Response Costs: Str Juan de Fuca …………………………….. 31
Table 21: Shoreline Impact and Bbl Oil Removed: Str Juan de Fuca …………………….. 34
Table 22: Modeled Oil Spill Response Costs (w/o Shore/Disposal): Outer Coast……. …... 37
Table 23: Estimated Total Response Costs: Outer Coast ………………………………….. 38
Table 24: Shoreline Impact and Bbl Oil Removed: Outer Coast …...……………………… 39
Table 25: Modeled Oil Spill Response Costs (w/o Shore/Disposal): Columbia River…….. 41
Table 26: Estimated Total Response Costs: Columbia River …………………………….. 42
Table 27: Shoreline Impact and Bbl Oil Removed: Columbia River …...………………….. 44
Table 28: Comparison of Shoreline Oiling by Response Capability/Method: Crude ……. 46
Table 29: Comparison of Mean Response Costs by Response Capability/Method: Crude . 47
Table 30: Comparison of Shoreline Oiling by Response Capability/Method: Diesel……… 48
Table 31: Comparison of Mean Response Costs by Response Capability/Method: Diesel . 48
Table 32: Comparison of Shoreline Oiling by Response Capability/Method: Bunker…… 49
Table 33: Comparison of Mean Response Costs by Response Capability/Method: Bunker 50

Overview of Oil Spill Response Costs

Oil spill response costs vary by at least two orders of magnitude when viewed on a per-gallon or per-barrel basis, as shown in Figure 1. This makes simple cost estimations based on per-unit rates highly unreliable.



Each oil spill – and the costs associated with its cleanup response – is a unique event. But, there are patterns that emerge when reviewing historical oil spill case studies and contingency plans. The costs associated with oil spill response operations are strongly influenced by the specific circumstances surrounding the spill including: the type of oil product spilled; the location and timing of the spill; sensitive areas affected or threatened; local and national laws; the amount of oil spilled; and spill response strategy. The influence of these factors on oil spill response costs are reviewed in greater detail elsewhere (Etkin 1998*a*, 1998*b*, 1998*c*, 1999*a*, 2000, 2004).

Arguably, the most important determinant of cleanup costs is *location*. Location itself is a complex factor involving geographical, political, and legal considerations. The timing of a spill, both seasonally and diurnally (*e.g*., tide cycles), can profoundly influence the nature and sensitivity of the geographical location. Both geographical location and timing can have a profound effect on the type and level of oil removal required with regards to logistics, type and amount of equipment required, personnel required, amount of work required, and available spill response options. Local or regional standards for the degree of "cleanliness" required for shoreline response operations are also key to determining costs.

Oil type is another important factor in determining oil spill response costs. It is considerably more time-consuming and, thus, more expensive to remove heavier oils than lighter ones. Heavier oils also require expensive decontamination processes for equipment and

Response strategy can also influence costs. Overall, dispersion or burning of oil on the water surface to prevent shoreline contamination tends to reduce overall response costs (Etkin 1998*a*, 1999*b*, 2000; Moller, Parker, and Nichols 1987). Shoreline cleanup is often the most time-consuming, labor-intensive, and costly part of a spill response.

Smaller spills are generally more expensive on a per-gallon basis due to the investment in initial mobilization of resources, personnel, and monitoring officials that is then averaged over a smaller number of gallons of oil. There can even be considerable expenses realized when there is merely the *threat* of oil spillage and response resources need to be mobilized on a precautionary basis.

Estimating response costs for hypothetical oil spill scenarios should rely heavily on patterns and data from previous oil spill cases. Since the number of moderate- to larger oil spills has decreased in recent years (Etkin 2001*a*, Etkin 2001c; 2003*a*, 2004*b*), there are fewer spills on which to base oil spill response cost models. Rather than relying exclusively on costs derived from past spills, it is also possible to enhance cost estimates by studying costs for resource and personnel allocations for hypothetical scenarios in area contingency plans and exercises. This also allows for oil spill costs to be estimated for hypothetical spills that are unlike other spills that have occurred in the past.

A combination of actual and modeled hypothetical spill response costs has been employed in various studies (Etkin 2001*c*, 2001*d*, 2004*a*; Etkin *et al.* 2003; Etkin *et al.* 2002; Etkin and Tebeau 2003; French-McCay *et al.* 2004). This methodology is also employed in the current study.

The question of "accuracy" for oil spill cost estimates arises when modeling hypothetical responses to hypothetical spill scenarios. It is virtually impossible to truly accurately predict the cost of any spill response, because there are too many unknown factors. The actual efficacy of spill response equipment and work crews, weather and other factors that can influence response progress, and the possibility of strategic or judgmental errors on the part of response officials or spill managers are all difficult to predict.

Another important set of factors that can influence costs, but also are difficult to foresee, are contractual problems, irregularities, errors, or even improprieties on the part of spill response contractors and spill management teams. There can be tremendous differences in the rates that spill response contractors charge to clients (responsible parties) that already have contractual agreements and those that do not. In addition, there are different governmental and commercial rates that come into play depending on whether the contractors are being hired directly by the responsible party or by government officials, who will then later seek reimbursement to the Oil Spill Liability Trust Fund from the responsible party, if known.

Washington Oil Spill Scenarios Modeled

The trajectory, oil removal, and shoreline impact results from SIMAP modeling of the oil spill scenarios shown in Table 1 were used to estimate response costs. Each "scenario" consists of a specific amount and type of oil spilled in a specific *location* (single site or along a shipping lane), coupled with a response strategy. Different response strategies were applied to the same type of spill (oil type and amount) in the same location.

Table 1: WASHINGTON OIL SPILL SCENARIOS

Scenario No.[1]	Location	Spill Type[2,3]	Modeled Response							
			No[4]	Mechanical[5]			Mechanical + Dispersant[6]			Mechanical + ISB[7]
				Fed	State	3rd	Fed	State	3rd	State
OUTER COAST										
OC-Crud-N	Duntz Rock NW of Cape Flattery	65,000 bbl ANS crude	●							
OC-Crud-R-Fed	Duntz Rock NW of Cape Flattery	65,000 bbl ANS crude		●						
OC-Crud-R-ST	Duntz Rock NW of Cape Flattery	65,000 bbl ANS crude			●					
OC-Crud-R-3	Duntz Rock NW of Cape Flattery	65,000 bbl ANS crude				●				
OC-Crud-C-Fed	Duntz Rock NW of Cape Flattery	65,000 bbl ANS crude					●			
OC-Crud-C-ST	Duntz Rock NW of Cape Flattery	65,000 bbl ANS crude						●		
OC-Crud-C-3	Duntz Rock NW of Cape Flattery	65,000 bbl ANS crude							●	
OC-Crud-R-ISB	Duntz Rock NW of Cape Flattery	65,000 bbl ANS crude								●
STRAIT OF JUAN DE FUCA (NEAH BAY TO DUNGENESS SPIT)										
S1-Bunk-N	Neah Bay /Dungeness Spit	25,000 bbl Bunker C	●							
S1-Bunk-R-Fed	Neah Bay /Dungeness Spit	25,000 bbl Bunker C		●						
S1-Bunk-R-ST	Neah Bay /Dungeness Spit	25,000 bbl Bunker C			●					
S1-Bunk-R-3	Neah Bay /Dungeness Spit	25,000 bbl Bunker C				●				
S1-Bunk-R-ISB	Neah Bay /Dungeness Spit	25,000 bbl Bunker C								●
S1-Dies-N	Neah Bay /Dungeness Spit	65,000 bbl Diesel	●							
S1-Dies-R-Fed	Neah Bay /Dungeness Spit	65,000 bbl Diesel		●						
S1-Dies-R-ST	Neah Bay /Dungeness Spit	65,000 bbl Diesel			●					
S1-Dies-R-3	Neah Bay /Dungeness Spit	65,000 bbl Diesel				●				

Table 1: WASHINGTON OIL SPILL SCENARIOS *(continued)*

Scenario No.[1]	Location	Spill Type[2,3]	Modeled Response							
			No[4]	Mechanical[5]			Mechanical + Dispersant[6]			Mechanical + ISB[7]
				Fed	State	3rd	Fed	State	3rd	State
STRAIT OF JUAN DE FUCA (NEAH BAY TO PORT ANGELES)										
S2-Crud-N	Neah Bay/Port Angeles	65,000 bbl ANS crude	●							
S2-Crud-R-Fed	Neah Bay/Port Angeles	65,000 bbl ANS crude		●						
S2-Crud-R-ST	Neah Bay/Port Angeles	65,000 bbl ANS crude			●					
S2-Crud-R-3	Neah Bay/Port Angeles	65,000 bbl ANS crude				●				
S2-Crud-C-Fed	Neah Bay/Port Angeles	65,000 bbl ANS crude					●			
S2-Crud-C-ST	Neah Bay/Port Angeles	65,000 bbl ANS crude						●		
S2-Crud-C-3	Neah Bay/Port Angeles	65,000 bbl ANS crude							●	
S2-Crud-R-ISB	Neah Bay/Port Angeles	65,000 bbl ANS crude								●
SAN JUAN ISLANDS										
SI-Crud-N	Rosario/Georgia Strait S Lopez Island to Cherry Pt.	65,000 bbl ANS crude	●							
SI-Crud-R-Fed	Rosario/Georgia Strait S Lopez Island to Cherry Pt.	65,000 bbl ANS crude		●						
SI-Crud-R-ST	Rosario/Georgia Strait S Lopez Island to Cherry Pt.	65,000 bbl ANS crude			●					
SI-Crud-R-3	Rosario/Georgia Strait S Lopez Island to Cherry Pt.	65,000 bbl ANS crude				●				
SI-Crud-C-Fed	Rosario Strait/S Lopez Island to Pt. Lawrence	65,000 bbl ANS crude					●			
SI-Crud-C-ST	Rosario Strait/S Lopez Island to Pt. Lawrence	65,000 bbl ANS crude						●		
SI-Crud-C-3	Rosario Strait/S Lopez Island to Pt. Lawrence	65,000 bbl ANS crude							●	
IS-Crud-N	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude	●							
IS-Crud-R-Fed	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude		●						
IS-Crud-R-ST	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude			●					
IS-Crud-R-3	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude				●				
IS-Crud-C-Fed	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude					●			
IS-Crud-C-ST	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude						●		
IS-Crud-C-3	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude							●	

Table 1: WASHINGTON OIL SPILL SCENARIOS *(continued)*										
Scenario No.[1]	**Location**	**Spill Type[2,3]**	**Modeled Response**							
			No[4]	**Mechanical[5]**			**Mechanical + Dispersant[6]**			**Mechanical + ISB[7] State**
				Fed	**State**	**3rd**	**Fed**	**State**	**3rd**	
INNER STRAITS (PUGET SOUND)										
IS-Crud-N	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude	●							
IS-Crud-R-Fed	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude		●						
IS-Crud-R-ST	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude			●					
IS-Crud-R-3	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude				●				
IS-Crud-C-Fed	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude					●			
IS-Crud-C-ST	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude						●		
IS-Crud-C-3	Port Angeles to south end of Lopez Island	65,000 bbl ANS crude							●	
COLUMBIA RIVER (WEST)										
C1-Bunk-N	3 miles off entrance to Columbia River to Astoria	25,000 bbl Bunker C	●							
C1-Bunk-R-Fed	3 miles off entrance to Columbia River to Astoria	25,000 bbl Bunker C		●						
C1-Bunk-R-ST	3 miles off entrance to Columbia River to Astoria	25,000 bbl Bunker C			●					
C1-Bunk-R-3	3 miles off entrance to Columbia River to Astoria	25,000 bbl Bunker C				●				
COLUMBIA RIVER (EAST)										
C1-Bunk-N	Portland to Longview	25,000 bbl Bunker C	●							
C1-Bunk-R-Fed	Portland to Longview	25,000 bbl Bunker C		●						
C1-Bunk-R-ST	Portland to Longview	25,000 bbl Bunker C			●					
C1-Bunk-R-3	Portland to Longview	25,000 bbl Bunker C				●				

[1] Scenario numbers based on: location (OC = outer coast; S1, S2 = Strait of Juan de Fuca; SI = San Juan Islands; IS = Inner Straits; C1, C2 = Columbia River);oil type (crud = crude; dies = diesel; bunk = Bunker C); response type (R = "removal" for mechanical recovery only or *in-situ* burning; C = chemical dispersant application); and response level (N = no response; Fed = federal response capabilities; ST = state response capabilities; and 3 = hypothetical 3rd alternative response capabilities). [2] bbl = barrels (equivalent to 42 gallons). [3] ANS crude = Alaska North Slope crude. [4] "No response" means no *on-water* recovery or dispersion attempted. Protective booming, shoreline cleanup, salvage, and spill management/monitoring conducted as required. [5] On-water mechanical response conducted using federal, state, or hypothetical 3rd alternative response capabilities. Protective booming, shoreline cleanup, salvage, disposal, and spill management/monitoring conducted as required. [6]Dispersant applications conducted where permitted by state guidelines with concurrent mechanical response using federal, state, or hypothetical 3rd alternative response capabilities. Protective booming, shoreline cleanup, salvage, disposal, and spill management/monitoring conducted as required. [7]ISB = *in situ* burning conducted according to state guidelines with concurrent mechanical response using *state* response capabilities. Protective booming, shoreline cleanup, salvage, disposal, and spill management/monitoring conducted as required.

Response Strategies

The response strategies applied in the modeled scenarios are shown in Table 2.

TABLE 2: RESPONSE STRATEGY COMPONENTS FOR MODELED RESPONSE TYPES

Response Type	On-Water Mechanical Containment/ Recovery[1]	Dispersant Application[2]	In-Situ Burning[3]	Protective Boom[4]	Salvage (Source Control)[5]	Spill Mgt.[6]	Monitor[7]	Shoreline Cleanup[8]	Disposal[9]
No Response[10]				●	●	●	●	●	●
Mechanical	●			●	●	●	●	●	●
Mechanical + Dispersant	●	●		●	●	●	●	●	●
Mechanical + ISB[11]	●		●	●	●	●	●	●	●

[1] On-water containment and recovery operations, including booms, skimmers, vacuum trucks, boats, oil herding, oil containment, and helicopter/small plane overflights to direct responders, according to either federal, state, or hypothetical 3rd alternative response capabilities, as shown in Table Z. [2] Dispersants applied in locations permitted by state guidelines. [3] *In-situ* burning conducted in locations permitted by state guidelines. [4] Protective booming applied in locations specified in Geographic Response Plans. [5] Salvage includes only source control – *i.e.*, those measures required to stop the leak in the vessel, remove remaining oil, and to steady or right the vessel sufficiently to reduce dangers to response workers and the public. This salvage does not include any repairs to the vessel to bring it back into operation or to reduce owner losses. [6] Spill management includes responsible party Qualified Individual services and management of response personnel and resources. [7] Monitoring includes the services of all governmental (state, federal, local) officials required to supervise response operations, including federal and state on-scene coordinators, as well overflights required to monitor response effectiveness and slick movement, communications, and unified command operations. [8] Shoreline cleanup includes all removal of oil from shoreline substrates by manual and mechanical methods, including the use of sorbents.

Response Capability

For all response strategies employing on-water mechanical containment and recovery (*i.e.*, all responses except "no response"), the mechanical response capability was specified by one of three levels of response capability (also referred to as "CAPS"):

- ***Federal:*** US Coast Guard Vessel and Facility Response Plans for Oil: 2003 Removal Equipment Requirements and Alternative Technology Revisions: Notice of Proposed Rulemaking. *Federal Register* Vol. 67 (198): pp. 63,331 – 63,452. 11 October 2002)
- ***State:*** current state guidance (proposed planning standards in WAC 173-181)
- ***3rd alternative:*** hypothetical higher response capability alternative as determined by Contingency Plan Rule Advisory Committee

The actual required response capability for each level consists of specifications for amounts of and timing of arrival for booming equipment, oil removal equipment (skimmers, vacuum trucks, oil recovery vessels), and oil storage equipment, depending on the location and amount of oil spilled. The response capability levels applied in this modeling study are shown in Tables 3 – 9. *(See also Figures* Note that for all response capability levels, the equipment amounts are *cumulative*.

TABLE 3: Mechanical Spill Response Capabilities: Outer Coast Spill 65,000 bbl ANS Crude												
	FEDERAL (Offshore)				**STATE**				**3RD ALTERNATIVE**			
Hr	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***
2	-	-	-	-	yes	-	-	-	yes	3,500	-	-
4	-	-	-	-	-	-	-	-		20,000	12,000	12,000
6	-	-	-	-	-	3,500	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	40,000	36,000	36,000	-	40,000	36,000	72,000
24	-	30,000	12,500	25,000	-	40,000+	48,000	96,000	-	40,000	48,000	144,000
48	-	30,000	25,000	50,000	-	40,000+	60,000	180,000	-	40,000	60,000	180,000
72	-	30,000	50,000	100,000	-	40,000	72,000	180,000+	-	-	-	-

TABLE 4: Mechanical Spill Response Capabilities: Strait of Juan de Fuca Spill 25,000 bbl Bunker C												
	FEDERAL (Nearshore)				**STATE**				**3RD ALTERNATIVE**			
Hr	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***
2	-	-	-	-	-	1,392	-	-	-	1,392	-	-
4	-	-	-	-	-	-	-	-	-	20,000	3,087	3,087
6	-	-	-	-	-	10,000	1,234.8	1,234.8	-	-	-	-
12	-	30,000	6,483	12,966		40,000	3,087	4,630.5	-	30,000	9,261	18,722
24	-	-	-	-	-	40,000+	7,408.8	14,817.6	-	40,000+	12,348	37,044
36	-	30,000	10,805	21,160	-	-	-	-	-	-	-	-
48	-	-	-	-	-	40,000+	10,495.8	31,487.4	-	40,000+	15,435	46,305
60	-	30,000	17,287	34,574	-	-	-	-	-	-	-	-
72	-	-	-	-	-	40,000+	12,348	31,487.4+	-	-	-	-

TABLE 5: Mechanical Spill Response Capabilities: Strait of Juan de Fuca Spill 65,000 bbl Diesel												
	FEDERAL (Nearshore)				**STATE**				**3RD ALTERNATIVE**			
Hr	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***
2	-	-	-	-	-	3,500	-	-	-	3,500	-	-
4	-	-	-	-	-	-	-	-	-	20,000	36,000	36,000
6	-	-	-	-	-	10,000	12,000	12,000	-	-	-	-
12	-	30,000	12,500	25,000	-	40,000	36,000	54,000	-	40,000	48,000	96,000
24	-	-	-	-	-	40,000	48,000	96,000	-	40,000	60,000	180,000
36	-	30,000	25,000	50,000	-	-	-	-	-	-	-	-
48	-	-	-	-	-	40,000	60,000	180,000	-	40,000	72,000	216,000
60	-	30,000	50,000	100,000	-	-	-	-	-	-	-	-
72	-	-	-	-	-	40,000+	72,000	180,000+	-	-	-	-

TABLE 6: Mechanical Spill Response Capabilities: Strait of Juan de Fuca Spill 65,000 bbl Crude

Hr	FEDERAL (Nearshore)				STATE				3RD ALTERNATIVE			
	Over-flight	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*	*Over-flight*	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*	*Over-flight*	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*
2	-	-	-	-	-	3,500	-	-	-	3,500	-	-
4	-	-	-	-	-	-	-	-	-	20,000	36,000	36,000
6	-	-	-	-	-	10,000	12,000	12,000	-	-	-	-
12	-	30,000	12,500	25,000		40,000	36,000	54,000	-	40,000	48,000	96,000
24	-	-	-	-	-	40,000	48,000	96,000	-	40,000	60,000	180,000
36	-	30,000	25,000	50,000	-	-	-	-	-	-	-	-
48	-	-	-	-	-	40,000	60,000	180,000	-	40,000	72,000	216,000
60	-	30,000	50,000	100,000	-	-	-	-	-	-	-	-
72	-	-	-	-	-	40,000+	72,000	180,000+	-	-	-	-

TABLE 7: Mechanical Spill Response Capabilities: San Juan Islands Spill 65,000 bbl ANS Crude

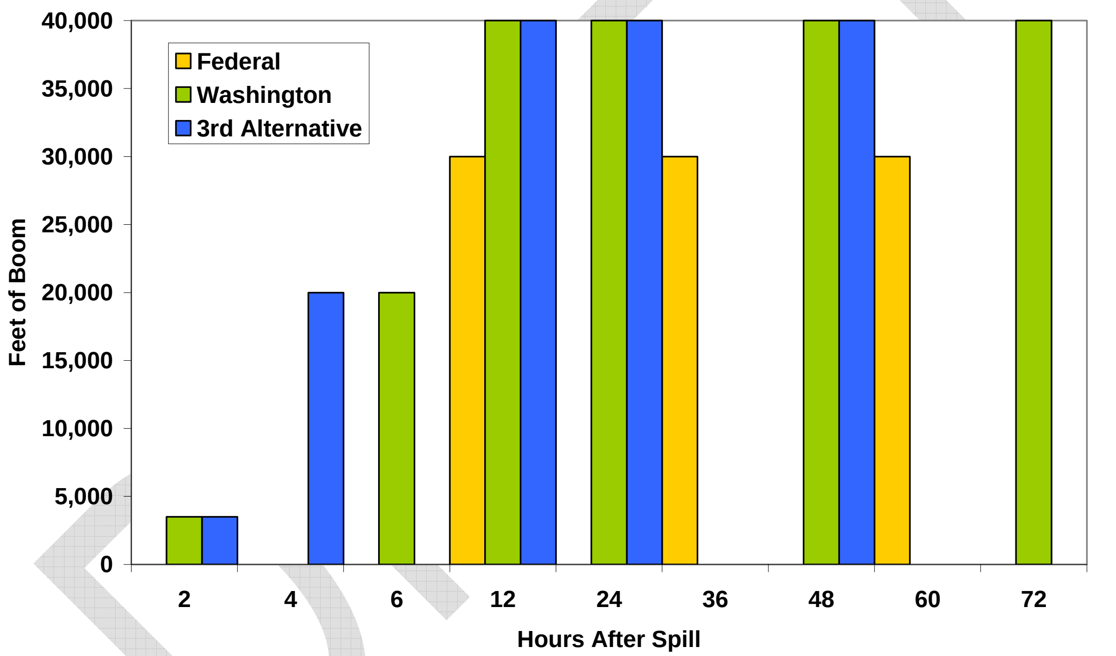
Hr	FEDERAL (Nearshore)				STATE				3RD ALTERNATIVE			
	Over-flight	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*	*Over-flight*	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*	*Over-flight*	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*
2	-	-	-	-	-	3,500	-	-	-	3,500	-	-
4	-	-	-	-	-	-	-	-	-	20,000	36,000	36,000
6	-	-	-	-	-	20,000	12,000	12,000	-	-	-	-
12	-	30,000	12,500	25,000	-	40,000	36,000	54,000	-	40,000	48,000	56,000
24	-	-	-	-	-	40,000+	48,000	96,000	-	40,000	60,000	180,000
36	-	30,000	25,000	50,000	-	-	-	-	-	-	-	-
48	-	-	-	-	-	40,000	60,000	120,000	-	40,000	72,000	216,000
60	-	30,000	50,000	100,000	-	-	-	-	-	-	-	-
72	-	-	-	-	-	40,000+	72,000	120,000+	-	-	-	-

TABLE 8: Mechanical Spill Response Capabilities: Inner Straits Spill 65,000 bbl ANS Crude

Hr	FEDERAL (Nearshore)				STATE				3RD ALTERNATIVE			
	Over-flight	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*	*Over-flight*	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*	*Over-flight*	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*
2	-	-	-	-	-	3,500	-	-	-	3,500	-	-
4	-	-	-	-	-	-	-	-	-	20,000	36,000	36,000
6	-	-	-	-	-	20,000	12,000	12,000	-	-	-	-
12	-	30,000	12,500	25,000		40,000	36,000	54,000	-	40,000	48,000	56,000
24	-	-	-	-	-	40,000+	48,000	96,000	-	40,000	60,000	180,000
36	-	30,000	25,000	50,000	-	-	-	-	-	-	-	-
48	-	-	-	-	-	40,000	60,000	120,000	-	40,000	72,000	216,000
60	-	30,000	50,000	100,000	-	-	-	-	-	-	-	-
72	-	-	-	-	-	40,000+	72,000	120,000+	-	-	-	-

TABLE 9: Mechanical Spill Response Capabilities: Columbia River Spill 25,000 bbl Bunker C												
	FEDERAL (River)				**STATE**				**3RD ALTERNATIVE**			
Hr	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***	***Over-flight***	***Boom (ft)***	***Recovery (bpd)***	***Storage (bpd)***
2	-	-	-	-	-	1,392	-	-	-	1,392	-	-
4	-	-	-	-	-	-	-	-	-	20,000	3,087	3,087
6	-	-	-	-	-	10,000	1,234.8	1,234.8	-	-	-	-
12	-	-	-	-	-	40,000	3,087	-	-	30,000	9,261	18,522
24	-	30,000	5,186	10,372	-	40,000+	7,408.8	14,817.6	-	40,000+	12,348	37,044
36	-	-	-	-	-	-	-	-	-	-	-	-
48	-	30,000	6,915	13,830	-	40,000+	10,495.8	20,991.6	-	40,000	15,345	46,305
60	-	30,000	10,372	20,744	-	40,000+	12,348	20,990+	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-

Figure 2: Comparative Oil Spill Response Capabilities: Booms
(65,000-bbl Spill Inner Straits and San Juan Islands)



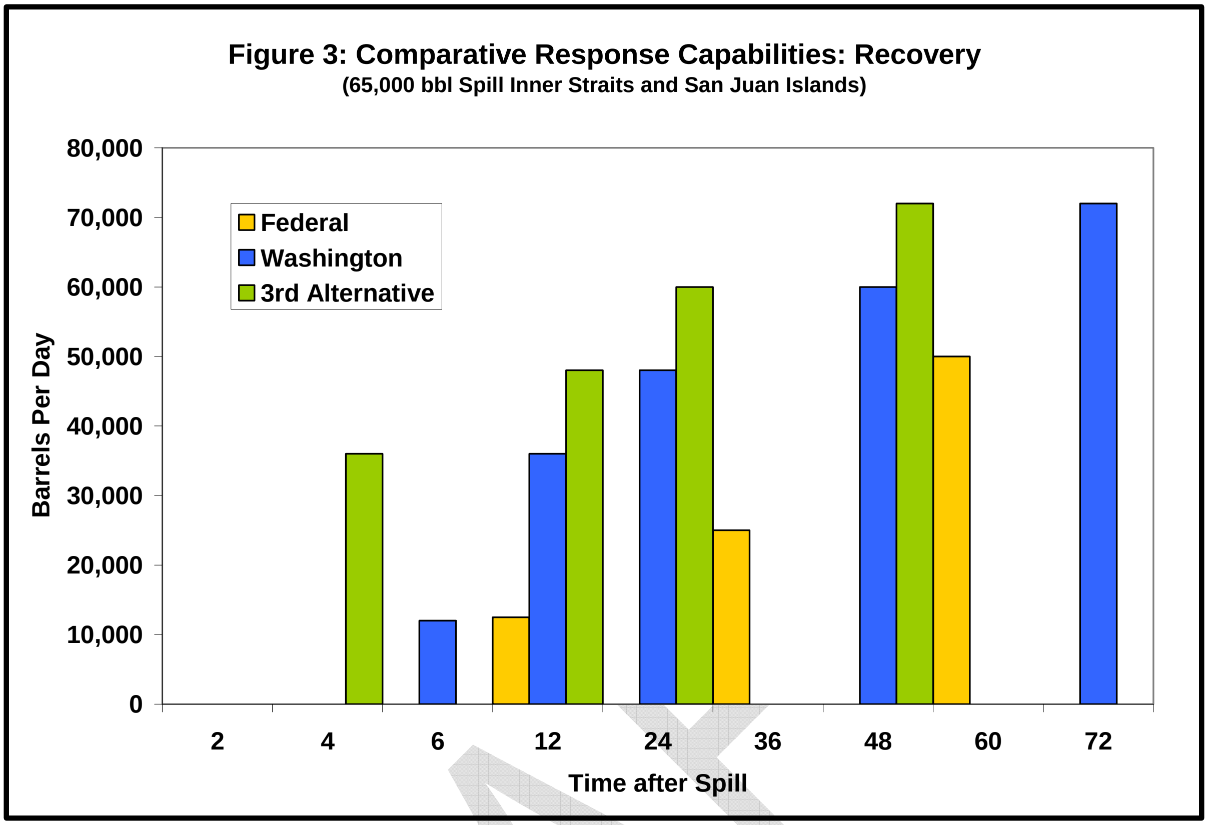


Figure 3: Comparative Response Capabilities: Recovery
(65,000 bbl Spill Inner Straits and San Juan Islands)
Barrels Per Day
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Federal
Washington
3rd Alternative
2
4
6
12
24
36
48
60
72
Time after Spill

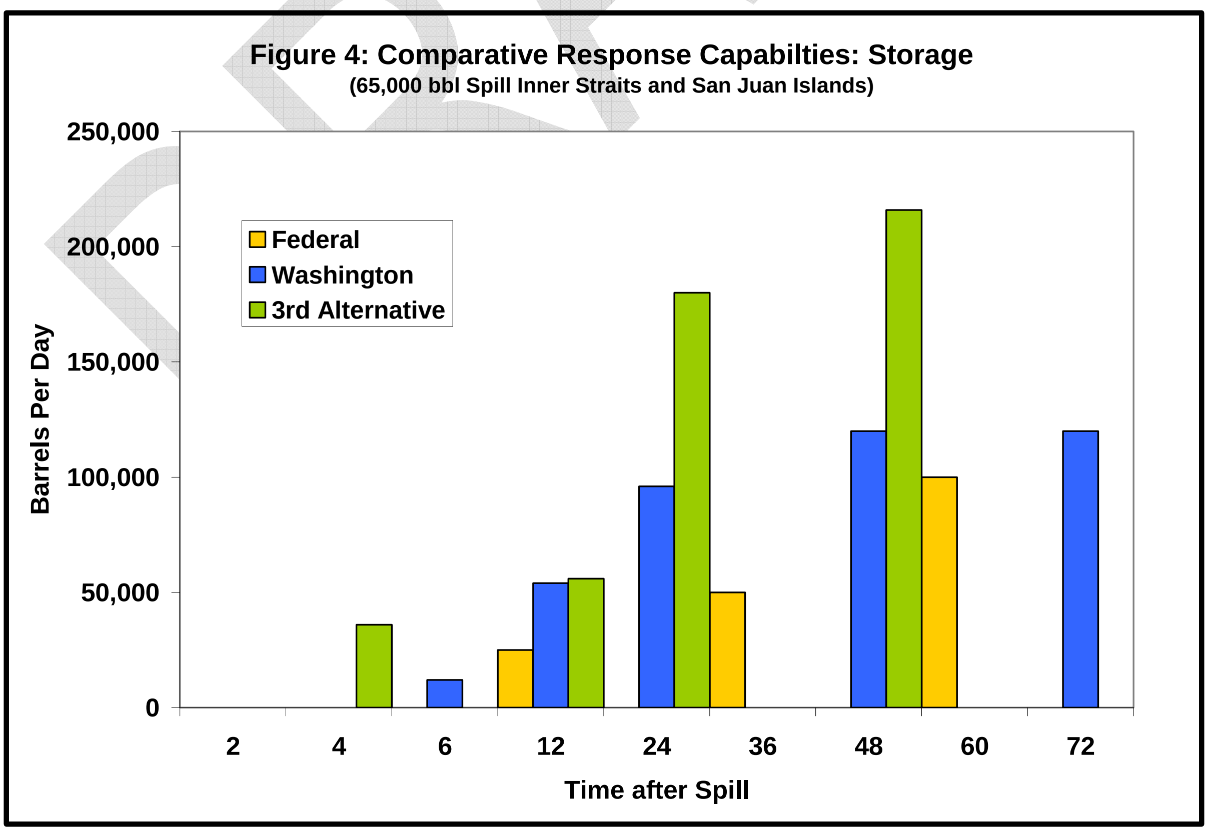


Figure 4: Comparative Response Capabilties: Storage
(65,000 bbl Spill Inner Straits and San Juan Islands)
Barrels Per Day
250,000
200,000
150,000
100,000
50,000
0
Federal
Washington
3rd Alternative
2
4
6
12
24
36
48
60
72
Time after Spill

Available Mechanical Response Equipment
Mechanical containment and recovery equipment available was based on information provided to the Contingency Plan Rule Advisory Committee from Washington Primary Response Contractors and equipment listed in the Northwest Area Contingency Plan and US Coast Guard District 13 oil spill response equipment database. Equipment to fulfill the various response capability levels was assumed to be available, in good working condition, and handled by competent, trained personnel.

Mechanical Response Equipment Effectiveness
In the modeling, mechanical recovery and storage equipment was assumed to be operating at the Effective Daily Recovery Capability (EDRC) rate (“recovery”) and storage capacities as shown in the response capability tables (Tables 3 – 9).

The computer modeling used in this study assumes that any oil that is on the water surface of sufficient thickness (set at 13 microns or 0.0005 inches, based on guidance in API, *et al.* 2001) could be corralled with containment boom and recovered with oil removal equipment (skimmers, vacuum trucks, or oil recovery vessels). This would be the equivalent of responders being directed from observers in helicopters and small planes that could detect the presence of oil visually or with other aids. In actual field applications of oil spill removal equipment, the recovery rate is rarely higher than 15 – 25% due to inefficiencies of response operations in locating, containing, and recovering oil. Adjustments to the model results were made to take this more realistic mechanical recovery effectiveness into account by comparing *shoreline* cleanup costs for the completely effective mechanical recovery (at the different response capability levels) and the “no response” scenarios for each location. Any oil not recovered on the water would eventually impact nearby shorelines. The estimated realistic response costs for shoreline cleanup were then assumed to be in the range of 85% (representing a 15% mechanical recovery efficiency) of the no-response shoreline cleanup costs to the maximum of completely effective on-water recovery as modeled.

Booming
Containment, deflection, and protective booms were assumed to be of the type required for “inland” environments, as per US Coast Guard vessel response plan regulations in 33 CFR 155 (US Coast Guard 1996). Boom height was assumed to be 18 to 42 inches and capable of withstanding a significant wave height of up to 3 feet. Entrainment (oil escaping under or splashing over the boom) was assumed to occur when wave heights exceeded 3 feet or current velocity exceeded 1 knot. It was assumed that the booms would have been properly deployed at angles that would allow withstanding of currents up to 1 knot (Fingas 2001). Booms were placed to protect sensitive resources based on maps in the Geographic Response Plans associated with the 2003 Northwest Area Contingency Plan. The large number of locations included is shown in Figure 5. Note that only booms that were in the general vicinity of the expected spill trajectory would actually have been deployed and are assumed deployed in the modeling.

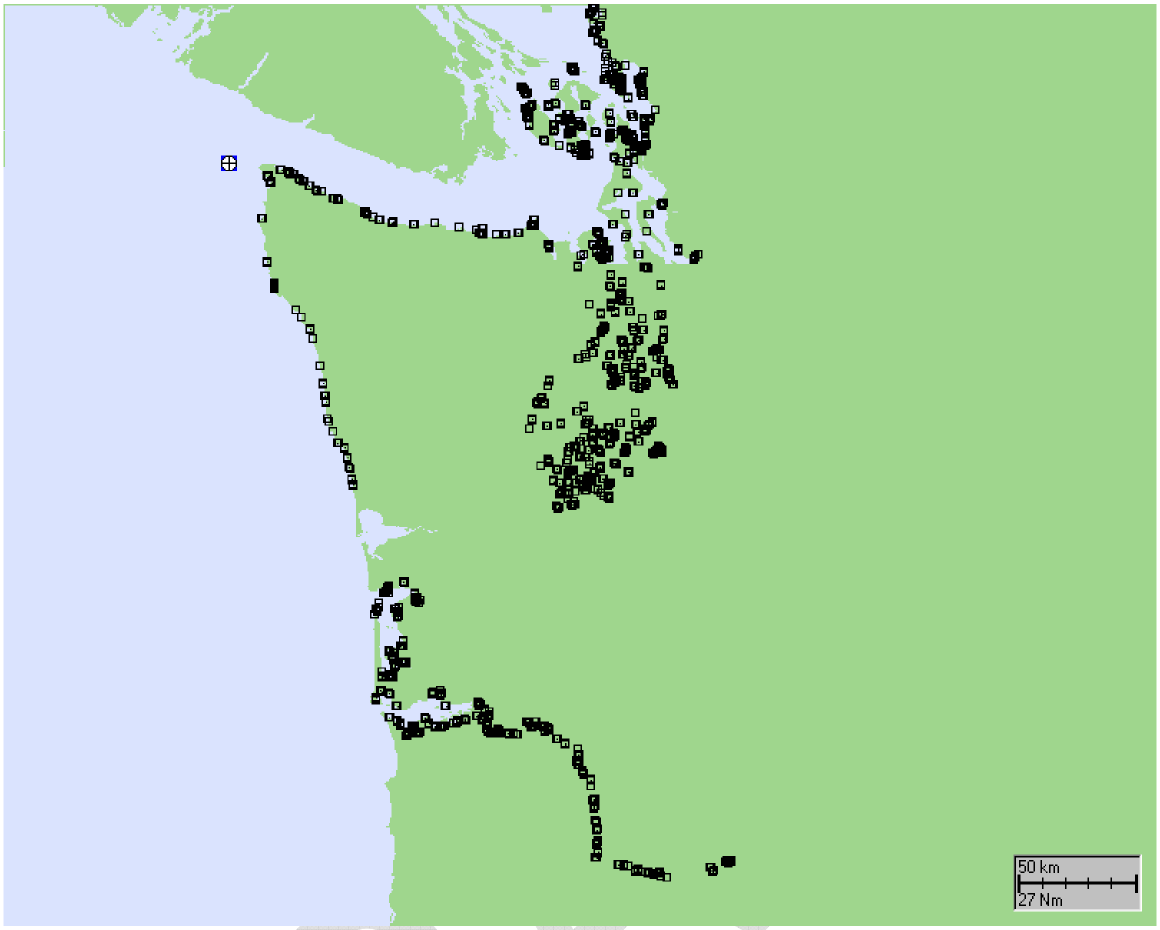


Figure 5: Location of protective booms as per Geographic Response Plans associated with the 2003 Northwest Area Contingency Plan. Note that only booms that were in the general vicinity of the expected spill trajectory would actually have been deployed and are assumed deployed in the modeling.

Canadian and Oregonian Response Levels

Since it could be expected that because of the geography of Washington and its waters, it would be likely that most major oil spills that occurred in the waters of the Outer Coast, Inner Straits of Puget Sound, Strait of Juan de Fuca, and San Juan Islands area would involve an impact on British Columbia, Canada, it was assumed that a Canadian oil spill response would take place. To put the largest theoretical stress on Washington response capabilities, it was assumed that the Canadian response would always be at a level equal to the lowest of the three response capabilities – the federal response capability – regardless of Washington’s response level. Likewise, spills in the Columbia River would likely affect Oregon waters and initiate a response from Oregon’s response system. It was assumed that Oregon’s response would be the equivalent of the federal response capability standards, regardless of Washington’s response level. When Washington responders were modeled to be using alternative response strategies as adjuncts to mechanical containment and recovery, Canadian and Oregonian responders were assumed to be employing only mechanical methods.

In-Situ Burning Operations

Modeling assumptions for *in-situ* burning operations in relevant scenarios were as follows:

- Wind speed was less than 25 knots (10.3 meters per second) (Allen 2004; Fingas and Punt 2000; US Coast Guard 1999);

- Wave height was less than three feet (Northwest Area Contingency Plan 2003; Fingas and Punt 2000; US Coast Guard 1999);

- When the current was greater than one knot, there can be no burning as there can be no effective booming (Northwest Area Contingency Plan 2003);

- Burns were at least three nautical miles from any shoreline (Allen 2004; US Coast Guard 1999; NOAA 1998);

- Burns were at least six nautical miles from any areas inhabited by more than 10,000 persons (Northwest Area Contingency Plan 2003; US Coast Guard 1999; NOAA 1997);

- Oil thickness was a minimum of 2 mm thick for *ignition* and, once burning, was minimum of 1 mm (Fingas and Punt 2000; ; NOAA 1998)) (Note: this is interpreted by the model as 13 microns averaged across the oil slick.);

- Burning operations could be conducted at a rate of three 500-bbl/day burns daily – i.e., 1,500 bbl per day (Allen 2004);

- Each burn took one hour (Allen 2004);

- Burning occurred at a rate of 5,000 liters per m^s per day up to 1,500 bbl for a whole day (Allen 2004; Fingas and Punt 2000; NOAA 1998);

- Maximum burn efficiency was 50% (Allen 2004);

- Burns only took place during daylight hours (assume 8am to 6pm) (Allen 2004);

- Remaining oil]was removed, as possible, with mechanical recovery at state mechanical response capabilities level; and

- Burning continues until oil reaches 50% emulsification (weathering) and/or oil was too thin (Northwest Area Contingency Plan 2003).

Based on the criteria for distance from shoreline and distance from heavily populated areas, the in situ burning "zones" were assumed to be as shown in Figure 6.

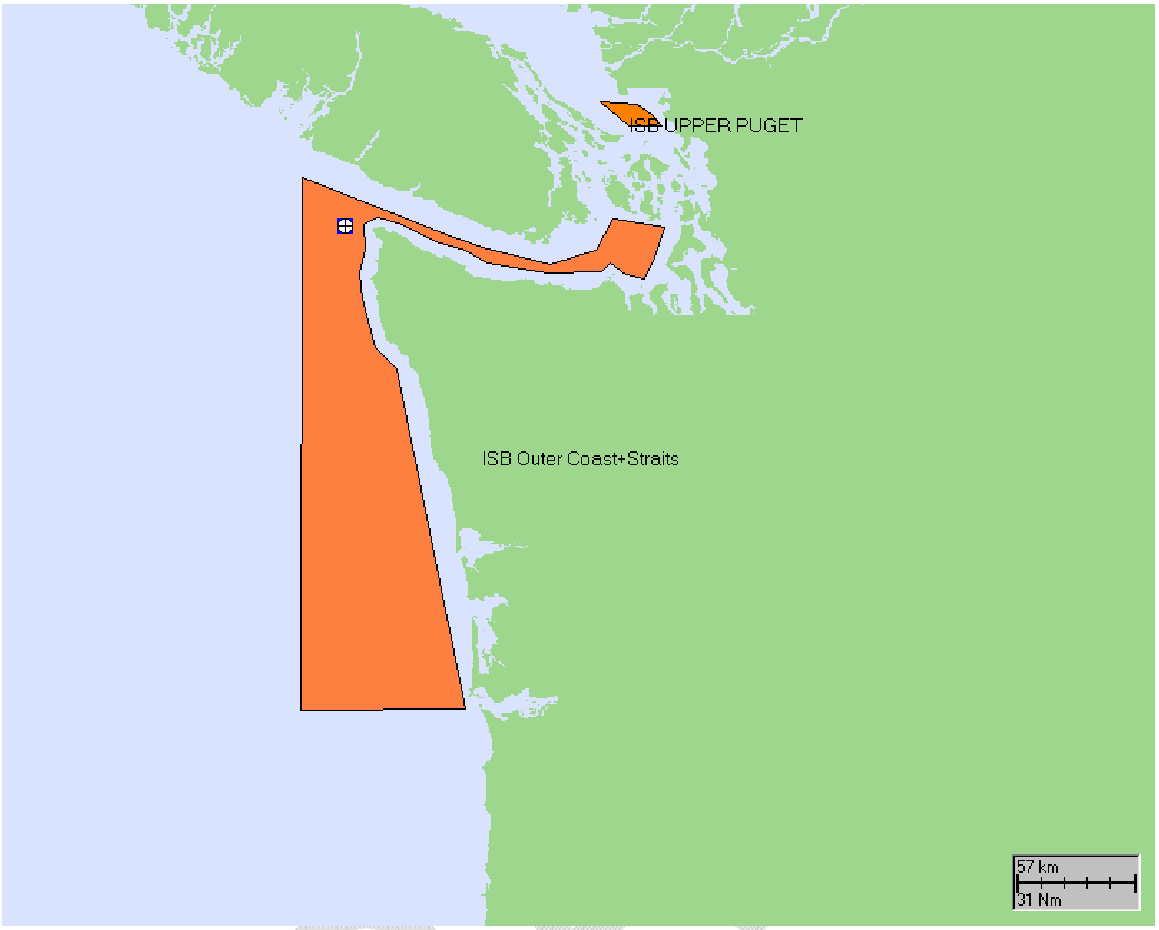


Figure 6: Areas of assumed *in-situ* burning application in SIMAP modeling.

Dispersant Operations

Assumptions for the dispersant operations modeling were as follows:

- Wind speed was 3 and 27 knots (1.3 to 11.1 meters per second) (API, *et al.* 2001; NOAA 1998);

- Dispersant application occurred at least 3 n miles from shoreline (API, *et al.* 2001; ; NOAA 1998);

- Oil thickness was minimum of 13 microns (French and Payne 2001);

- Dispersants were applied during daylight hours (8am to 6pm) (API, *et al.* 2001);

- Undispersed oil was removed, as possible, with mechanical recovery at state, federal, or hypothetical 3rd alternative response capability levels;

- Mechanical recovery operations were initiated as per state, federal, or hypothetical 3rd alternative response capability levels regardless of the timing of the arrival of dispersant plane sorties;

- Dispersant removal efficiency was 45% based on minimum effectiveness of dispersants for listing in US EPA National Contingency Plan Product Schedule J (Pond, Aurand, and Kraley 2000; US Environmental Protection Agency 2003). A previous study had shown that varying theoretical dispersant effectiveness from 45% to 80% did not appreciably change the oil effectively dispersed when the dispersants were applied after 8 hours after the spill onset (French-McCay and Payne 2001).

- Dispersants were applied according to the US Coast Guard CAPS report (USCG 1999) existing planning factors, applied in three tiers involving several C-130 aircraft sorties (flights without reloading). Tier 1 would require delivery of 4,125 gallons of dispersant at hour 8 or at first daylight – 884 bbl oil removal per hour. In this modeling study, hour 8 was considered more practicable than the US Coast Guard's hour 7 due to the planes needing to come from Alaska (personal communication, Richard Wright, Clean Sound Cooperative). The other dispersant applications occurred as per the schedule shown in Table 10.

Table 10: Schedule of Dispersant Applications

Hour	Gallons Dispersant Applied	Barrels Oil Dispersed Per Hour[1]
8	4,125	884
14	5,495	1,178
16	5,495	1,178
18	5,495	1,178
20	5,495	1,178
22	1,395	299
27	5,495	1,178
29	5,495	1,178
31	5,495	1,178
33	5,495	1,178
35	1,395	299

[1]The schedule was delayed for darkness.

- Dispersants were assumed to be applied in the areas shown in Figure 7. These areas are based on the dispersant application criteria in the Northwest Area Contingency Plan 2003 of distances of at least three nautical miles from shore.

- All necessary dispersant approvals and/or authorizations were in place.

- All airplanes equipped with dispersant application equipment (ADDSPACK-equipped C-130 aircraft) were available for deployment from Alaska.

- Weather conditions were suitable for flying airplanes and conducting all other aspects of dispersant application safely and with sufficient precision to be successful.

- The dispersant-to-oil ratio used in all operations was 1:20 (5 gallons/acre).

- Corexit 9500 was applied to Bunker C and Corexit 9527 was applied to crude oil.

- Both Corexit 9500 and Corexit 9527 were available within the time period required.

- Hourly charges for the C-130 aircraft (including field operational support, administrative support, and depreciation) would follow US Coast Guard standard rates for non-government operations.

- Two additional hours of C-130 aircraft usage costs are factored in to allow for transit to and from spill site.

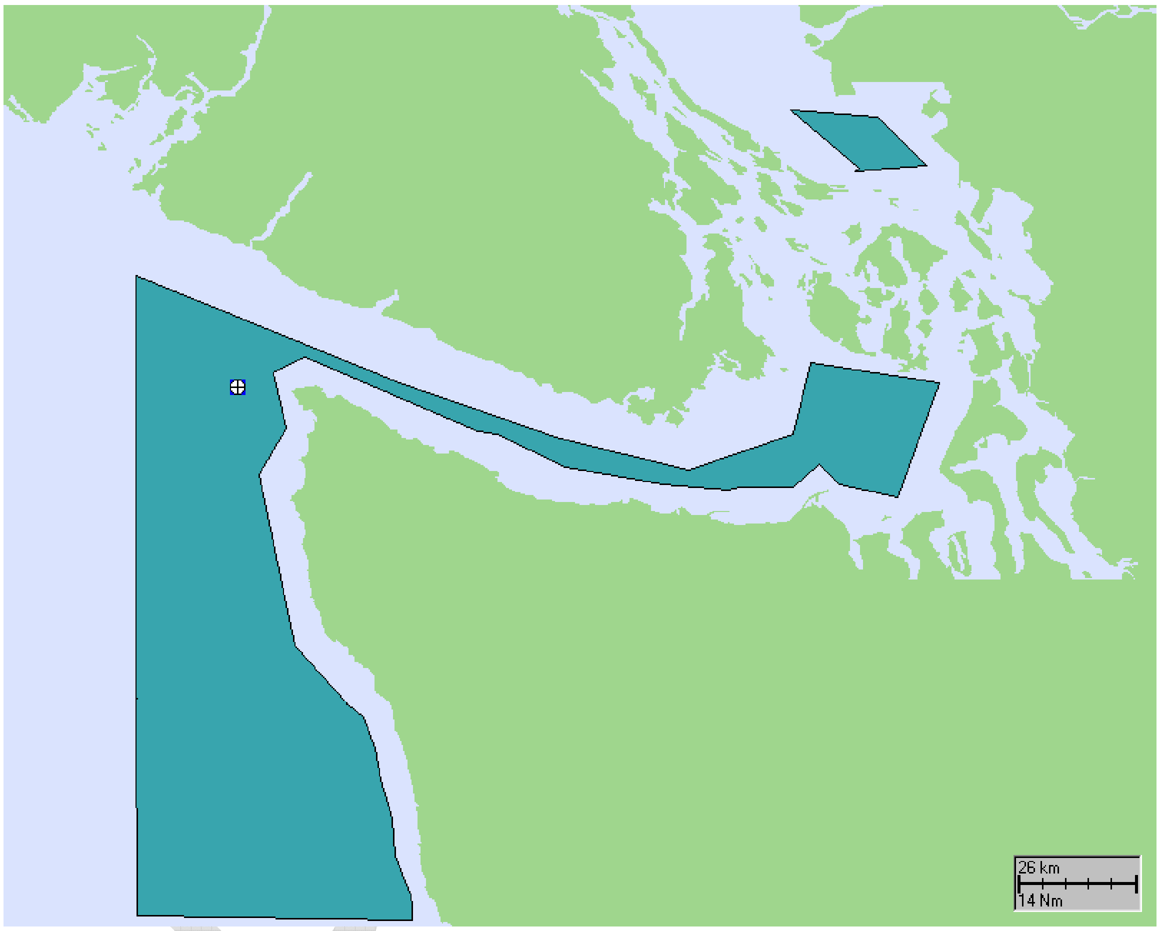


Figure 7: Areas assumed for dispersant operations in SIMAP modeling.

Assumptions for Modeling of Oil Spill Response Costs

Total response costs for the scenarios are the sum total of the following categories of costs: mobilization, protective booming, mechanical containment and recovery operations, spill management, spill monitoring by government officials, salvage (source control and stabilization), shoreline cleanup, decontamination of equipment and worker clothing/gear, wildlife rescue and rehabilitation, disposal of collected oil and debris, dispersant application operations and chemical dispersants (where applicable), and *in-situ* burning operations (where applicable). These costs do not include any costs associated with restoration of natural resources. (Restoration costs are included under natural resource damages in an accompanying report by Applied Science Associates, Inc.)

The assumptions made in estimating the costs for each of these categories are as follows:

- ***Mobilization:*** This is the initial mobilization of response equipment and personnel as would be required at the notification of a major oil spill. These costs are based on the costs typically seen in past spills and for equipment-deployment spill exercises. The costs are assumed to $500,000 for all spills, even for "no response", since it is likely that an initial response mobilization would occur for all spills regardless of whether the resources are then sent back.

- ***Protective Boom:*** Boom costs are based on the amount of boom deployed as per the applicable state response capabilities (as in Tables 3 – 9) for Washington and as per the federal capabilities for Oregon and Canada. The costs are based on typical commercial costs for boom on a per-foot daily basis for the estimated time that booms would be in transit to and from the spill site and in place on site.

- ***Mechanical:*** Costs for mechanical containment and recovery equipment, personnel, and logistics based on the deployment of the relevant response capabilities for the amount of time it would be required to have equipment and personnel in transit to and from the site as well as the time that the oil on the water surface is at least 13 microns in thickness based on the fates and trajectory modeling in SIMAP. Additional time is added for decontamination and demobilization. Costs are also based on spill size and oil type.

  For *in-situ* and dispersant scenarios, mechanical recovery is assumed to be operating at a 25% reduced rate, as per the 25% assumed mechanical response reduction in the US Coast Guard *Vessel and Facility Response Plans for Oil: 2003 Removal Equipment Requirements and Alternative Technology Revisions: Notice of Proposed Rulemaking* (US Coast Guard 2002). Costs are thus 75% of costs for scenarios in which mechanical recovery is the only on-water response strategy.

  The pay scales for workers are based on a comprehensive survey of Basic Ordering Agreements made with the US Coast Guard (USCG) Office of Maintenance and Logistics for the 13th US Coast Guard District updated to 2003 dollars and adjusted for commercial rates. Wages are paid as: 67% straight wages, 20% premium wages, and 13% overtime wages. Cleanup crews work for 12-hour workdays. Crews consist of: 1% project managers, 3% supervisors, 67% skilled laborers, and 29% unskilled laborers. Worker numbers and ratios of worker types were verified by a review of Area Contingency Plans (*e.g.*, North Coast California; Central Coast California; San Francisco Bay & Delta, Baltimore; Long Angeles/Long Beach; Mid-Coast Atlantic; Galveston, Texas; Port Arthur, Texas; San Diego; New York/New Jersey), Incident Action Plans from past spills (*e.g.*, Cape Mohican; PEPCO Pipeline; New Carissa; Morris J. Berman), and oil company contingency plans. Equipment rental rates are based on a comprehensive survey of Basic Ordering Agreements made with the USCG Office of Maintenance and Logistics for the 13th US Coast Guard District updated to 2003 dollars and adjusted for commercial rates. Helicopter overflights are charged for 12-hour days (times two helicopters) for the entire time oil is present on the water surface, including for "no-response" scenarios. Costs for shore-based support for skimming systems are assumed to be 12% of on-water costs (based on Michel and Cotsapas 1997).

- ***Spill Management/Spill Monitoring:*** Costs for responsible party-related spill management (Qualified Individual services and spill management teams) and response-related activities by responsible party personnel are based on reviews of previous responses to major spills in the ERC Oil Spill Cost Databases and other studies (*e.g*., Etkin 1995; Michel, French-McCay and Etkin 2001, 2002). The costs are based on the level of effort required based on response type, spill size, and oil type (based on persistence, as in Davis, *et al.* 2004). The costs are assumed to be $2 million for "no response" scenarios and 25,000-bbl in-situ burning scenarios for all oil types; $4 million for 65,000-bbl-dispersant and in-situ burning scenarios for all oil types, for 65,000-bbl diesel mechanical only scenarios, and for 25,000-bbl mechanical only scenarios; and $8 million for 65,000-bbl mechanical-only crude scenarios.

  Costs for federal, state, and local officials involved in overseeing and coordinating spill response operations are also included in this category. These costs are based on historical spill cases and estimates for government officials' time at $55,000 per day of on-water spill response operations and $10,000 per day during shoreline cleanup operations (Etkin 1995; Etkin 1998*b*; Michel, French-McCay, and Etkin 2001, 2002).

- ***Salvage***: Costs to control the source of leakage (tanker, cargo vessel, or barge), lighter remaining oil off vessel, and stabilize the vessel for public safety are included. Costs for repairing the vessel for future use by the owner or to sell the vessel are not included. Costs are based on information from US Maritime Administration and Navy SupSalv (Michel, French-McCay and Etkin 2001, 2002), as well as data from the Morris J. Berman tank barge spill (Etkin 1995). Costs are adjusted based on the size of the vessel and the type of oil involved. The costs are estimated to be: $8 million for crude tanker spills; $6 million for diesel tanker spills; and $3 million for Bunker C barge or cargo vessel spills.

- ***Wildlife Rescue/Rehabilitation:*** Capture, treatment, and rehabilitation costs for oil-impacted and injured wildlife are included in this category. Costs are based on historical spill data, particularly the Exxon Valdez oil spill (Monahan and Maki 1991; Etkin 1998*b*). Estimates for wildlife rescue and rehabilitation services for "no response" scenarios are $1 million for Bunker C spills (25,000 bbl), $3 million for crude spills (65,000 bbl), and $1 million for diesel spills (65,000 bbl). Costs were adjusted by 50% for reduced shoreline oiling with on-water recovery, burning, or dispersion. Costs are incurred for wildlife rescue and rehabilitation services to be on standby as well as for actual services rendered. These costs do not include "injuries" to wildlife or rehabilitation of habitats that are covered under "natural resource damages."

- ***Shoreline Cleanup:*** Shoreline cleanup costs are based on area of oil impact by shoreline type and oil type (Etkin 2001*d*, 2003*b*). The characteristics of oil (as in Table 11) and the characteristics of the substrate (rocky, gravel, wetland, sand, *etc.*) influence the degree of penetration, persistence, and adhesion. All these factors determine the amount of labor necessary to remove the oil from impacted shorelines. In addition, some shoreline types – notably wetlands and mudflats – are extremely sensitive to the impacts of the spill response itself (moving of machinery and personnel) so that extraordinary measures need to be taken, making these shoreline types more expensive to clean up. Shoreline cleanup cost factors on a per area basis by oil type and shoreline type are shown in Table 12. Note that these costs do not include the disposal of oily debris and solid waste collected. Shoreline cleanup is assumed to continue at a rate of 2,000 m^2/day.

Table 11: Influence of Oil Properties on Oil Impact in Environment[1]

Oil Type	Viscosity	Adhesion	Penetration	Degradation
Gasoline	1	1	5	4
Diesel	2	2	4	1
Crude	4	4	2	3
Heavy fuel oil	5	5	1	5

[1]Lower numbers indicate more favorable conditions to the environment and faster recovery after a spill (based on Fingas 2001).

Table 12: Shoreline Cleanup Cost Factors

Oil Type	Bunker C		Diesel		ANS Crude	
Shoreline Type	**<1 mm**	**>1 mm**	**<1 mm**	**>1 mm**	**<1 mm**	**>1 mm**
Rocky shoreline	$14	$78	$4	$2	$7	$39
Gravel beach	$20	$140	$5	$3	$10	$70
Sand beach	$24	$78	$6	$3	$12	$39
Mud flat	$70	$156	$18	$10	$35	$78
Wetland	$80	$172	$21	$11	$40	$86
Artificial	$8	$46	$2	$1	$4	$23

Year 2003 $ per m^2
Not including disposal costs

- ***Disposal:*** Costs for the disposal of oil recovered on the water during mechanical containment and recovery operations as well as oily debris recovered from oil-impacted shorelines are included in this category. Oil disposal rates are based on a comprehensive survey of Basic Ordering Agreements made with the US Coast

Guard Office of Maintenance and Logistics for the all US Coast Guard Districts updated to 2003 $. The costs are $216 per barrel of oil recovered mechanically and $150 per m^2 shoreline impact of greater than 0.1mm. The costs *assume an emulsification factor of four* – i.e., for each barrel of oil recovered, there are four barrels for disposal/separation due to emulsification) (Etkin 1995). Maximum disposal costs are estimated by assuming unsuccessful on-water recovery.

- ***Decontamination:*** Removal of oil residue from equipment and personnel gear is assumed to be $100 per barrel of crude removed $200 per barrel of Bunker C removed, based on historical spill case studies, notably the Morris J. Berman barge spill (Etkin 1995) and the persistence of the oils (Davis *et al.* 2004; Fingas 2001). Only $10 per barrel recovered decontamination costs were added for diesel spills since the oil residue evaporates and is not persistent. For "no response" scenarios, a cost for decontaminating protective boom was estimated at $500,000 for crude and Bunker C spills.

- ***In-Situ Burn Operations:*** Costs for in-situ burning operations are assumed to be $80 per bbl oil burned up to 1,500 bbl per day until oil is less than 13 microns thick (based on Allen and Ferek 1993, updated to 2003 costs).

- ***Dispersant Operations:*** The costs for dispersant operations include costs for planes with operators (40 hours x $6,000/hr x 3 planes = $720,000) and costs for dispersant chemicals ($45/gallon dispersant applied or ordered to be applied). The cost for dispersant chemicals comes to $2.3 million based on three tiers of sorties applying total of 50,875 gallons dispersant.

Oil Spill Response Cost Modeling Results

Oil spill response costs were estimated for each of the scenarios (varying spill location, oil type and amount, and response capability and strategy. Costs were estimated for all offshore response operations (mechanical recovery, dispersant application, and *in-situ* burning) and all other aspects of the spill response (management, monitoring, protective booming, and salvage), as well as for variable shoreline and disposal operations costs. The costs for shoreline operations were adjusted to take into account realistic inefficiencies in on-water recovery efforts. Adjustments to the model results were made by comparing *shoreline* cleanup costs for the completely effective mechanical recovery scenarios (at the different response capability levels) and the "no response" scenarios for each location. Any oil not recovered on the water would eventually impact nearby shorelines, after adjusting for evaporation and dispersion. The estimated *realistic* response costs for shoreline cleanup were then assumed to be in the range of 85% (representing a 15% mechanical recovery efficiency) of the no-response shoreline cleanup costs to the maximum of completely effective on-water recovery as modeled. For each scenario area, the cost results are presented in two parts. The first tables include the offshore response, overall monitoring/management operations, salvage, and protective booming other. The second tables represent the variable shoreline cleanup and disposal costs, along with total variable costs.

San Juan Islands Scenarios

Estimated cost results for the San Juan Islands scenarios are in Tables 13 – 14, with shore impacts and oil removal rates shown in Table 15.

Table 13: Modeled Oil Spill Response Costs Excluding Shoreline Response Costs and Disposal Costs: San Juan Islands Scenarios (Costs in 1,000 dollars)

Scenario	Per-centile	Mobilize[1]	Boom[2]	Mech[3]	Mgt + Monitor[4]	Salvage[5]	Decon[6]	ISB[7]	Disp Ops[8]	Wild-life[9]	Non-Shoreline Non-Disposal TOTAL[10]
SI-Crud- N	5th	$500	$13,600	$60	$3,974	$8,000	$500	0	0	$3,000	$29,634
	50th	$500	$13,600	$60	$3,025	$8,000	$500	0	0	$3,000	$28,685
	95th	$500	$13,600	$60	$3,205	$8,000	$500	0	0	$3,000	$28,865
SI-Crud-R-Fed	5th	$500	$13,600	$5,972	$8,685	$8,000	$4,564	0	0	$3,000	$44,321
	50th	$500	$13,600	$5,972	$8,815	$8,000	$4,363	0	0	$3,000	$44,250
	95th	$500	$13,600	$5,972	$9,057	$8,000	$3,832	0	0	$3,000	$43,961
SI-Crud-R-ST	5th	$500	$13,600	$6,788	$8,584	$8,000	$4,826	0	0	$3,000	$45,298
	50th	$500	$13,600	$6,474	$8,713	$8,000	$4,676	0	0	$3,000	$44,963
	95th	$500	$13,600	$6,788	$8,982	$8,000	$4,341	0	0	$3,000	$45,211
SI-Crud-R-3	5th	$500	$13,600	$6,611	$8,510	$8,000	$4,936	0	0	$3,000	$45,157
	50th	$500	$13,600	$6,611	$8,698	$8,000	$4,912	0	0	$3,000	$45,321
	95th	$500	$13,600	$6,611	$8,832	$8,000	$4,637	0	0	$3,000	$45,180
SI-Crud-C-Fed	5th	$500	$13,600	$5,144	$4,769	$8,000	$3,869	0	$3,000	$3,000	$41,882
	50th	$500	$13,600	$4,452	$4,790	$8,000	$3,941	0	$3,000	$3,000	$41,283
	95th	$500	$13,600	$4,452	$5,063	$8,000	$3,166	0	$3,000	$3,000	$40,781
SI-Crud-C-ST	5th	$500	$13,600	$5,410	$4,577	$8,000	$4,184	0	$3,000	$3,000	$42,271
	50th	$500	$13,600	$5,064	$4,774	$8,000	$4,296	0	$3,000	$3,000	$42,234
	95th	$500	$13,600	$4,830	$4,921	$8,000	$3,810	0	$3,000	$3,000	$41,661
SI-Crud-C-3	5th	$500	$13,600	$6,233	$4,498	$8,000	$4,450	0	$3,000	$3,000	$43,281
	50th	$500	$13,600	$5,887	$4,718	$8,000	$4,524	0	$3,000	$3,000	$43,229
	95th	$500	$13,600	$5,887	$4,825	$8,000	$4,197	0	$3,000	$3,000	$43,009

[1]Initial mobilization of resources, including equipment and personnel, at first notification of major spill. These costs are charged to responsible party regardless of whether the equipment/personnel are ever deployed. [2]Protective booming of sensitive resources based on Geographic Response Plans associated with Northwest Area Contingency Plan. [3]On-water mechanical containment and recovery operations, including equipment and personnel. [4]Spill management, qualified individual services, and other responsible-party associated costs, and government monitoring costs. [5]Salvage or source control to stop leak of oil, lighter vessel, and protect public safety. [6]Decontamination of oiled equipment, worker clothing, *etc.* [7]*In-situ* burning operations, including planes, ignition equipment and fuel, personnel, and monitoring of airborne particulates. [8]Dispersant operations, including planes, personnel, and monitoring, and dispersant chemicals. [9]Wildlife rescue, treatment, and rehabilitation. [10]This sub-total does not include shoreline cleanup operations or disposal of on-water or on-shore collected oil and debris.

Table 14: Estimated Total Response Costs: San Juan Islands Scenarios (Costs in 1,000 dollars)								
Scenario	**Percentile Run**	**Non-Shore/Disp TOTAL**	**Shoreline**		**Disposal**		**TOTAL**	
			Min	**Max**	**Min**	**Max**	**Min**	**Max**
SI-Crud-N	**5th**	$29,634	$20,748	$20,748	$74,019	$74,019	**$124,401**	**$124,401**
	50th	$28,685	$9,849	$9,849	$38,419	$38,419	**$76,953**	**$76,953**
	95th	$28,865	$14,247	$14,247	$45,178	$45,178	**$88,290**	**$88,290**
	Mean	$29,061	$14,947	$14,947	$52,539	$52,539	**$96,548**	**$96,548**
	Mean + 2SD	$29,643	$25,910	$25,910	$74,371	$74,371	**$125,160**	**$125,160**
	Mean - 2SD	$28,479	$3,984	$3,984	$30,707	$30,707	**$67,936**	**$67,936**
SI-Crud-R-Fed	**5th**	$44,321	$1,386	$17,636	$16,389	$62,916	**$62,096**	**$124,873**
	50th	$44,250	$2,028	$8,372	$21,093	$32,656	**$67,371**	**$85,278**
	95th	$43,961	$5,229	$12,110	$28,700	$38,401	**$77,890**	**$94,472**
	Mean	$44,177	$2,329	$12,705	$22,061	$44,658	**$69,119**	**$101,541**
	Mean + 2SD	$44,398	$5,620	$22,024	$29,234	$63,215	**$78,404**	**$125,469**
	Mean - 2SD	$43,957	$0	$3,386	$14,887	$26,101	**$59,834**	**$77,613**
SI-Crud-R-ST	**5th**	$45,298	$580	$17,636	$13,508	$62,916	**$59,386**	**$125,850**
	50th	$44,963	$1,669	$8,372	$19,685	$32,656	**$66,317**	**$85,991**
	95th	$45,211	$3,668	$12,110	$27,361	$38,401	**$76,240**	**$95,722**
	Mean	$45,157	$1,736	$12,705	$20,185	$44,658	**$67,314**	**$102,521**
	Mean + 2SD	$45,358	$3,634	$22,024	$28,198	$63,215	**$77,096**	**$126,517**
	Mean - 2SD	$44,957	$0	$3,386	$12,171	$26,101	**$57,533**	**$78,525**
SI-Crud-R-3	**5th**	$45,157	$560	$17,636	$12,993	$62,916	**$58,710**	**$125,709**
	50th	$45,321	$1,511	$8,372	$19,463	$32,656	**$66,295**	**$86,349**
	95th	$45,180	$2,818	$12,110	$24,607	$38,401	**$72,605**	**$95,691**
	Mean	$45,219	$1,501	$12,705	$19,021	$44,658	**$65,870**	**$102,583**
	Mean + 2SD	$45,322	$3,148	$22,024	$25,741	$63,215	**$73,904**	**$126,330**
	Mean - 2SD	$45,117	$0	$3,386	$12,301	$26,101	**$57,836**	**$78,837**
SI-Crud-C-Fed	**5th**	$41,882	$1,114	$17,636	$15,004	$62,916	**$58,000**	**$122,434**
	50th	$41,283	$1,837	$8,372	$20,171	$32,656	**$63,291**	**$82,311**
	95th	$40,781	$5,421	$12,110	$28,835	$38,401	**$75,037**	**$91,292**
	Mean	$41,315	$2,790	$12,705	$21,337	$44,658	**$65,443**	**$98,679**
	Mean + 2SD	$41,952	$7,403	$22,024	$29,407	$63,215	**$75,512**	**$122,993**
	Mean - 2SD	$40,679	$0	$3,386	$13,267	$26,101	**$55,374**	**$74,365**
SI-Crud-C-ST	**5th**	$42,271	$5,721	$17,636	$13,027	$62,916	**$61,019**	**$122,823**
	50th	$42,234	$1,650	$8,372	$19,919	$32,656	**$63,803**	**$83,262**
	95th	$41,661	$3,561	$12,110	$27,153	$38,401	**$72,375**	**$92,172**
	Mean	$42,055	$1,693	$12,705	$20,033	$44,658	**$65,732**	**$99,419**
	Mean + 2SD	$42,450	$3,552	$22,024	$28,189	$63,215	**$72,567**	**$123,382**
	Mean - 2SD	$41,660	$0	$3,386	$11,877	$26,101	**$58,898**	**$75,457**
SI-Crud-C-3	**5th**	$43,281	$472	$17,636	$12,562	$62,916	**$56,315**	**$123,833**
	50th	$43,229	$1,609	$8,372	$20,205	$32,656	**$65,043**	**$84,257**
	95th	$43,009	$2,758	$12,110	$24,382	$38,401	**$70,149**	**$93,520**
	Mean	$43,173	$1,613	$12,705	$19,050	$44,658	**$63,836**	**$100,537**
	Mean + 2SD	$43,340	$3,899	$22,024	$25,971	$63,215	**$71,913**	**$124,439**
	Mean - 2SD	$43,006	$0	$3,386	$12,128	$26,101	**$55,758**	**$76,635**

Table 15: Shoreline Impact and Bbl Oil Removed: San Juan Islands Scenarios				
Scenario	**Percentile**	**Shoreline Impact (m^2)**	**Bbl Oil Removed**	**% Removed Offshore**
SI-Crud-N	**5th**	493,460	0	0%
	50th	256,128	0	0%
	95th	301,187	0	0%
	MEAN	350,259	0	0%
	MEAN + 2SD	621,491	0	0%
	MEAN - SD	79,027	0	0%
SI-Crud-R-Fed	**5th**	47,431	42,936	66%
	50th	79,903	42,163	65%
	95th	140,470	35,322	54%
	MEAN	68,009	40,065	62%
	MEAN + 2SD	167,137	45,996	71%
	MEAN - SD	0	34,135	53%
SI-Crud-R-ST	**5th**	22,256	47,081	72%
	50th	68,228	43,756	67%
	95th	121,679	42,173	65%
	MEAN	54,353	43,978	68%
	MEAN + 2SD	123,549	47,627	73%
	MEAN - SD	0	40,329	62%
SI-Crud-R-3	**5th**	17,514	47,992	74%
	50th	64,397	45,388	70%
	95th	97,964	45,893	71%
	MEAN	51,262	45,521	70%
	MEAN + 2SD	118,294	48,934	75%
	MEAN - SD	0	42,109	65%
SI-Crud-C-Fed	**5th**	41,046	40,960	63%
	50th	73,701	42,205	65%
	95th	142,112	34,808	54%
	MEAN	85,619	39,324	60%
	MEAN + 2SD	201,055	47,246	73%
	MEAN - SD	7,815	31,403	48%
SI-Crud-C-ST	**5th**	20,432	46,121	71%
	50th	69,687	43,822	67%
	95th	120,220	42,223	65%
	MEAN	53,486	43,214	66%
	MEAN + 2SD	122,128	47,364	73%
	MEAN - SD	0	39,064	60%
SI-Crud-C-3	**5th**	14,594	48,021	74%
	50th	69,505	45,274	70%
	95th	96,322	45,990	71%
	MEAN	60,140	46,428	71%
	MEAN + 2SD	148,948	49,279	76%
	MEAN - SD	0	43,578	67%

Inner Straits Scenarios

Estimated cost results for the Inner Straits scenarios are in Tables 16 – 17. Shoreline impact and oil removal are shown in Table 18.

Table 16: Modeled Oil Spill Response Costs Excluding Shoreline Response Costs and Disposal Costs: Inner Straits Scenarios (Costs in 1,000 dollars)

Scenario	Per-centile	Mobilize[1]	Boom[2]	Mech[3]	Mgt + Monitor[4]	Salvage[5]	Decon[6]	ISB[7]	Disp Ops[8]	Wild-life[9]	Non-Shoreline Non-Disposal TOTAL[10]
IS-Crud- N	**5th**	$500	$13,600	$60	$3,366	$8,000	$500	0	0	$3,000	**$29,026**
	50th	$500	$13,600	$60	$3,304	$8,000	$500	0	0	$3,000	**$28,964**
	95th	$500	$13,600	$60	$4,308	$8,000	$500	0	0	$3,000	**$29,968**
IS-Crud-R-Fed	**5th**	$500	$13,600	$5,972	$8,623	$8,000	$4,564	0	0	$3,000	**$44,259**
	50th	$500	$13,600	$5,972	$8,584	$8,000	$4,363	0	0	$3,000	**$44,019**
	95th	$500	$13,600	$5,972	$8,959	$8,000	$3,832	0	0	$3,000	**$43,863**
IS-Crud-R-ST	**5th**	$500	$13,600	$6,977	$8,507	$8,000	$4,826	0	0	$3,000	**$45,410**
	50th	$500	$13,600	$6,977	$8,615	$8,000	$4,676	0	0	$3,000	**$45,368**
	95th	$500	$13,600	$6,977	$8,904	$8,000	$4,341	0	0	$3,000	**$45,322**
IS-Crud-R-3	**5th**	$500	$13,600	$6,904	$8,498	$8,000	$4,936	0	0	$3,000	**$45,438**
	50th	$500	$13,600	$6,904	$8,675	$8,000	$4,912	0	0	$3,000	**$45,591**
	95th	$500	$13,600	$6,904	$8,766	$8,000	$4,637	0	0	$3,000	**$45,407**
IS-Crud-C-Fed	**5th**	$500	$13,600	$4,452	$4,531	$8,000	$3,869	0	$3,000	$3,000	**$40,952**
	50th	$500	$13,600	$4,452	$4,583	$8,000	$3,941	0	$3,000	$3,000	**$41,076**
	95th	$500	$13,600	$4,452	$4,877	$8,000	$3,166	0	$3,000	$3,000	**$40,595**
IS-Crud-C-ST	**5th**	$500	$13,600	$4,975	$4,452	$8,000	$4,184	0	$3,000	$3,000	**$41,711**
	50th	$500	$13,600	$5,206	$4,594	$8,000	$4,296	0	$3,000	$3,000	**$42,196**
	95th	$500	$13,600	$5,206	$4,823	$8,000	$3,810	0	$3,000	$3,000	**$41,939**
IS-Crud-C-3	**5th**	$500	$13,600	$4,933	$4,441	$8,000	$4,450	0	$3,000	$3,000	**$41,924**
	50th	$500	$13,600	$4,933	$4,490	$8,000	$4,524	0	$3,000	$3,000	**$42,047**
	95th	$500	$13,600	$4,933	$4,683	$8,000	$4,197	0	$3,000	$3,000	**$41,913**

[1]Initial mobilization of resources, including equipment and personnel, at first notification of major spill. These costs are charged to responsible party regardless of whether the equipment/personnel are ever deployed. [2]Protective booming of sensitive resources based on Geographic Response Plans associated with Northwest Area Contingency Plan. [3]On-water mechanical containment and recovery operations, including equipment and personnel. [4]Spill management, qualified individual services, and other responsible-party associated costs, and government monitoring costs. [5]Salvage or source control to stop leak of oil, lighter vessel, and protect public safety. [6]Decontamination of oiled equipment, worker clothing, *etc.* [7]*In-situ* burning operations, including planes, ignition equipment and fuel, personnel, and monitoring of airborne particulates. [8]Dispersant operations, including planes, personnel, and monitoring, and dispersant chemicals. [9]Wildlife rescue, treatment, and rehabilitation. [10]This sub-total does not include shoreline cleanup operations or disposal of on-water or on-shore collected oil and debris.

Table 17: Estimated Total Response Costs: Inner Straits Scenarios (Costs in 1,000 dollars)								
Scenario	**Percentile Run**	**Non-Shore/Disp TOTAL**	**Shoreline**		**Disposal**		**TOTAL**	
			Min	**Max**	**Min**	**Max**	**Min**	**Max**
IS-Crud-N	**5th**	$29,026	$7,353	$7,353	$32,645	$32,645	**$69,024**	**$69,024**
	50th	$28,964	$8,606	$8,606	$30,347	$30,347	**$67,917**	**$67,917**
	95th	$29,968	$18,923	$18,923	$68,000	$68,000	**$116,891**	**$116,891**
	Mean	$29,319	$11,627	$11,627	$43,664	$43,664	**$84,611**	**$84,611**
	Mean + 2SD	$29,969	$24,325	$24,325	$68,036	$68,036	**$116,897**	**$116,897**
	Mean - 2SD	$28,670	$0	$0	$19,292	$19,292	**$52,324**	**$52,324**
IS-Crud-R-Fed	**5th**	$44,259	$265	$6,250	$14,646	$27,748	**$59,170**	**$78,257**
	50th	$44,019	$1,127	$7,315	$12,761	$25,795	**$57,907**	**$77,129**
	95th	$43,863	$3,874	$16,085	$25,681	$57,800	**$73,418**	**$117,748**
	Mean	$44,047	$1,808	$9,883	$17,696	$37,114	**$63,498**	**$91,045**
	Mean + 2SD	$44,277	$4,758	$20,676	$25,755	$57,831	**$73,445**	**$117,756**
	Mean - 2SD	$43,817	$0	$0	$9,637	$16,398	**$53,552**	**$64,334**
IS-Crud-R-ST	**5th**	$45,410	$22	$6,250	$10,862	$27,748	**$56,294**	**$79,408**
	50th	$45,368	$1,080	$7,315	$14,615	$25,795	**$61,063**	**$78,478**
	95th	$45,322	$2,696	$16,085	$24,701	$57,800	**$72,719**	**$119,207**
	Mean	$45,367	$1,137	$9,883	$16,726	$37,114	**$63,359**	**$92,364**
	Mean + 2SD	$45,417	$2,745	$20,676	$24,990	$57,831	**$73,116**	**$119,212**
	Mean - 2SD	$45,316	$0	$0	$8,462	$16,398	**$53,602**	**$65,516**
IS-Crud-R-3	**5th**	$45,438	$6	$6,250	$10,771	$27,748	**$56,215**	**$79,436**
	50th	$45,591	$911	$7,315	$17,368	$25,795	**$63,870**	**$78,701**
	95th	$45,407	$1,867	$16,085	$20,168	$57,800	**$67,442**	**$119,292**
	Mean	$45,479	$1,008	$9,883	$16,102	$37,114	**$62,509**	**$92,476**
	Mean + 2SD	$45,592	$2,420	$20,676	$21,673	$57,831	**$69,132**	**$119,295**
	Mean - 2SD	$45,365	$0	$0	$10,531	$16,398	**$55,886**	**$65,657**
IS-Crud-C-Fed	**5th**	$40,952	$67	$6,250	$9,726	$27,748	**$50,745**	**$74,950**
	50th	$41,076	$879	$7,315	$11,824	$25,795	**$53,779**	**$74,186**
	95th	$40,595	$3,047	$16,085	$21,177	$57,800	**$64,819**	**$114,480**
	Mean	$40,874	$1,331	$9,883	$14,242	$37,114	**$56,448**	**$87,872**
	Mean + 2SD	$41,163	$4,412	$20,676	$21,282	$57,831	**$65,000**	**$114,484**
	Mean - 2SD	$40,586	$0	$0	$7,203	$16,398	**$47,895**	**$61,260**
IS-Crud-C-ST	**5th**	$41,711	$36	$6,250	$9,474	$27,748	**$51,221**	**$75,709**
	50th	$42,196	$647	$7,315	$13,000	$25,795	**$55,843**	**$75,306**
	95th	$41,939	$2,300	$16,085	$20,544	$57,800	**$64,783**	**$115,824**
	Mean	$41,949	$1,060	$9,883	$14,339	$37,114	**$57,282**	**$88,946**
	Mean + 2SD	$42,229	$2,590	$20,676	$20,869	$57,831	**$65,244**	**$115,825**
	Mean - 2SD	$41,668	$0	$0	$7,809	$16,398	**$49,321**	**$62,068**
IS-Crud-C-3	**5th**	$41,924	$2	$6,250	$9,639	$27,748	**$51,565**	**$75,922**
	50th	$42,047	$126	$7,315	$11,633	$25,795	**$53,806**	**$75,157**
	95th	$41,913	$1,472	$16,085	$18,177	$57,800	**$61,562**	**$115,798**
	Mean	$41,961	$533	$9,883	$13,150	$37,114	**$55,644**	**$88,959**
	Mean + 2SD	$42,047	$2,164	$20,676	$18,307	$57,831	**$61,702**	**$115,802**
	Mean - 2SD	$41,875	$0	$0	$7,809	$16,398	**$49,587**	**$62,116**

Table 18: Shoreline Impact and Bbl Oil Removed: Inner Straits Scenarios				
Scenario	**Percentile**	**Shoreline Impact (m^2)**	**Bbl Oil Removed**	**% Removed Offshore**
IS-Crud-N	**5th**	217,635	0	0%
	50th	202,313	0	0%
	95th	453,330	0	0%
	MEAN	291,096	0	0%
	MEAN + 2SD	572,544	0	0%
	MEAN - SD	9,920	0	0%
IS-Crud-R-Fed	**5th**	31,925	45,635	70%
	50th	22,256	43,625	67%
	95th	116,025	38,319	59%
	MEAN	54,030	41,288	64%
	MEAN + 2SD	142,668	48,178	74%
	MEAN - SD	0	34,399	53%
IS-Crud-R-ST	**5th**	2,919	48,262	74%
	50th	30,100	46,757	72%
	95th	102,159	43,414	67%
	MEAN	41,475	45,086	69%
	MEAN + 2SD	114,443	49,451	76%
	MEAN - SD	0	40,722	63%
IS-Crud-R-3	**5th**	730	49,357	76%
	50th	45,059	49,115	76%
	95th	67,681	46,370	71%
	MEAN	36,485	46,898	72%
	MEAN + 2SD	92,265	51,656	79%
	MEAN - SD	0	42,139	65%
IS-Crud-C-Fed	**5th**	9,121	38,692	60%
	50th	22,074	39,412	61%
	95th	95,593	31,659	49%
	MEAN	42,263	36,587	56%
	MEAN + 2SD	135,669	45,154	69%
	MEAN - SD	0	28,021	43%
IS-Crud-C-ST	**5th**	2,919	41,836	64%
	50th	24,810	42,958	66%
	95th	82,093	38,101	59%
	MEAN	38,952	41,773	64%
	MEAN + 2SD	108,046	46,772	72%
	MEAN - SD	0	36,774	57%
IS-Crud-C-3	**5th**	182	44,500	68%
	50th	12,405	45,244	70%
	95th	60,748	41,966	65%
	MEAN	24,446	43,903	68%
	MEAN + 2SD	89,478	47,341	73%
	MEAN - SD	0	40,466	62%

Strait of Juan de Fuca Scenarios

Estimated cost results for Strait of Juan de Fuca scenarios are in Tables 19 – 20. Shoreline impact and oil removal are shown in Table 21.

Table 19: Modeled Oil Spill Response Costs Excluding Shoreline Response Costs and Disposal Costs: Strait of Juan de Fuca Scenarios (Costs in 1,000 dollars)

Scenario	Per-centile	Mobilize[1]	Boom[2]	Mech[3]	Mgt + Monitor[4]	Salvage[5]	Decon[6]	ISB[7]	Disp Ops[8]	Wild-life[9]	Non-Shoreline Non-Disposal TOTAL[10]
S1-Bunk- N	**5th**	$500	$6,800	$60	$2,000	$3,000	$500	0	0	$1,000	**$13,860**
	50th	$500	$6,800	$60	$2,252	$3,000	$500	0	0	$1,000	**$14,112**
	95th	$500	$6,800	$60	$2,168	$3,000	$500	0	0	$1,000	**$14,028**
S1-Bunk-R-Fed	**5th**	$500	$6,800	$1,969	$4,000	$3,000	$4,591	0	0	$1,000	**$21,860**
	50th	$500	$6,800	$1,969	$4,615	$3,000	$4,373	0	0	$1,000	**$22,257**
	95th	$500	$6,800	$2,245	$4,768	$3,000	$4,088	0	0	$1,000	**$22,401**
S1-Bunk-R-ST	**5th**	$500	$6,800	$2,246	$4,000	$3,000	$4,544	0	0	$1,000	**$22,090**
	50th	$500	$6,800	$2,246	$4,613	$3,000	$4,379	0	0	$1,000	**$22,538**
	95th	$500	$6,800	$2,568	$4,773	$3,000	$4,005	0	0	$1,000	**$22,646**
S1-Bunk-R-3	**5th**	$500	$6,800	$2,292	$4,000	$3,000	$4,746	0	0	$1,000	**$22,338**
	50th	$500	$6,800	$2,292	$4,473	$3,000	$4,637	0	0	$1,000	**$22,702**
	95th	$500	$6,800	$2,633	$4,643	$3,000	$4,214	0	0	$1,000	**$22,790**
S1-Bunk-R-ISB	**5th**	$500	$6,800	$1,685	$2,000	$3,000	$4,600	$480	0	$1,000	**$20,065**
	50th	$500	$6,800	$1,685	$2,631	$3,000	$4,420	$480	0	$1,000	**$20,516**
	95th	$500	$6,800	$1,685	$2,592	$3,000	$4,703	$480	0	$1,000	**$20,760**
S1-Dies-N	**5th**	$500	$13,600	$30	$2,122	$6,000	$0	0	0	$1,000	**$23,252**
	50th	$500	$13,600	$30	$2,000	$6,000	$0	0	0	$1,000	**$23,130**
	95th	$500	$13,600	$30	$2,242	$6,000	$0	0	0	$1,000	**$23,372**
S1-Dies-R-Fed	**5th**	$500	$13,600	$5,290	$4,517	$6,000	$452	0	0	$1,000	**$31,359**
	50th	$500	$13,600	$1,640	$4,000	$6,000	$403	0	0	$1,000	**$27,143**
	95th	$500	$13,600	$4,478	$4,636	$6,000	$56	0	0	$1,000	**$30,270**
S1-Dies-R-ST	**5th**	$500	$13,600	$7,073	$4,509	$6,000	$480	0	0	$1,000	**$33,162**
	50th	$500	$13,600	$2,181	$4,000	$6,000	$462	0	0	$1,000	**$27,743**
	95th	$500	$13,600	$6,326	$4,654	$6,000	$70	0	0	$1,000	**$32,150**
S1-Dies-R-3	**5th**	$500	$13,600	$7,542	$4,456	$6,000	$518	0	0	$1,000	**$33,616**
	50th	$500	$13,600	$2,760	$4,000	$6,000	$492	0	0	$1,000	**$28,352**
	95th	$500	$13,600	$8,984	$4,943	$6,000	$120	0	0	$1,000	**$35,147**

[1]Initial mobilization of resources, including equipment and personnel, at first notification of major spill. These costs are charged to responsible party regardless of whether the equipment/personnel are ever deployed. [2]Protective booming of sensitive resources based on Geographic Response Plans associated with Northwest Area Contingency Plan. [3]On-water mechanical containment and recovery operations, including equipment and personnel. [4]Spill management, qualified individual services, and other responsible-party associated costs, and government monitoring costs. [5]Salvage or source control to stop leak of oil, lighter vessel, and protect public safety. [6]Decontamination of oiled equipment, worker clothing, *etc.* [7]*In-situ* burning operations, including planes, ignition equipment and fuel, personnel, and monitoring of airborne particulates. [8]Dispersant operations, including planes, personnel, and monitoring, and dispersant chemicals. [9]Wildlife rescue, treatment, and rehabilitation. [10]This sub-total does not include shoreline cleanup operations or disposal of on-water or on-shore collected oil and debris.

Table 19: Modeled Oil Spill Response Costs Excluding Shoreline Response Costs and Disposal Costs: Strait of Juan de Fuca Scenarios (Costs in 1,000 dollars) *(continued)*											
Scenario	**Per-centile**	**Mobilize[1]**	**Boom[2]**	**Mech[3]**	**Mgt + Monitor[4]**	**Salvage[5]**	**Decon[6]**	**ISB[7]**	**Disp Ops[8]**	**Wild-life[9]**	**Non-Shoreline Non-Disposal TOTAL[10]**
S2-Crud-N	**5th**	$500	$13,600	$60	$2,431	$8,000	$500	0	0	$3,000	**$28,091**
	50th	$500	$13,600	$60	$2,313	$8,000	$500	0	0	$3,000	**$27,973**
	95th	$500	$13,600	$60	$2,270	$8,000	$500	0	0	$3,000	**$27,930**
S2-Crud-R-Fed	**5th**	$500	$13,600	$5,696	$8,668	$8,000	$4,140	0	0	$3,000	**$43,604**
	50th	$500	$13,600	$5,290	$8,638	$8,000	$4,218	0	0	$3,000	**$43,246**
	95th	$500	$13,600	$6,100	$8,769	$8,000	$3,913	0	0	$3,000	**$43,882**
S2-Crud-R-ST	**5th**	$500	$13,600	$7,617	$8,557	$8,000	$4,725	0	0	$3,000	**$45,999**
	50th	$500	$13,600	$7,414	$8,698	$8,000	$4,446	0	0	$3,000	**$45,658**
	95th	$500	$13,600	$8,500	$8,828	$8,000	$4,021	0	0	$3,000	**$46,449**
S2-Crud-R-3	**5th**	$500	$13,600	$7,745	$8,441	$8,000	$5,068	0	0	$3,000	**$46,354**
	50th	$500	$13,600	$7,912	$8,636	$8,000	$4,382	0	0	$3,000	**$46,030**
	95th	$500	$13,600	$8,686	$8,723	$8,000	$4,230	0	0	$3,000	**$46,739**
S2-Crud-R-ISB	**5th**	$500	$13,600	$7,577	$4,551	$8,000	$4,785	$720	$3,000	$3,000	**$45,733**
	50th	$500	$13,600	$7,003	$4,611	$8,000	$4,482	$720	$3,000	$3,000	**$44,916**
	95th	$500	$13,600	$8,149	$4,772	$8,000	$4,014	$720	$3,000	$3,000	**$45,755**
S2-Crud-C-Fed	**5th**	$500	$13,600	$8,646	$4,629	$8,000	$3,278	0	$3,000	$3,000	**$44,653**
	50th	$500	$13,600	$7,904	$4,602	$8,000	$4,168	0	$3,000	$3,000	**$44,774**
	95th	$500	$13,600	$8,646	$4,723	$8,000	$3,884	0	$3,000	$3,000	**$45,353**
S2-Crud-C-ST	**5th**	$500	$13,600	$8,310	$4,440	$8,000	$3,827	0	$3,000	$3,000	**$44,677**
	50th	$500	$13,600	$7,939	$4,556	$8,000	$4,316	0	$3,000	$3,000	**$44,911**
	95th	$500	$13,600	$9,422	$4,790	$8,000	$3,961	0	$3,000	$3,000	**$46,273**
S2-Crud-C-3	**5th**	$500	$13,600	$7,996	$4,440	$8,000	$4,335	0	$3,000	$3,000	**$44,871**
	50th	$500	$13,600	$7,625	$4,524	$8,000	$4,384	0	$3,000	$3,000	**$44,633**
	95th	$500	$13,600	$8,828	$4,767	$8,000	$4,176	0	$3,000	$3,000	**$45,871**

[1]Initial mobilization of resources, including equipment and personnel, at first notification of major spill. These costs are charged to responsible party regardless of whether the equipment/personnel are ever deployed. [2]Protective booming of sensitive resources based on Geographic Response Plans associated with Northwest Area Contingency Plan. [3]On-water mechanical containment and recovery operations, including equipment and personnel. [4]Spill management, qualified individual services, and other responsible-party associated costs, and government monitoring costs. [5]Salvage or source control to stop leak of oil, lighter vessel, and protect public safety. [6]Decontamination of oiled equipment, worker clothing, *etc.* [7]*In-situ* burning operations, including planes, ignition equipment and fuel, personnel, and monitoring of airborne particulates. [8]Dispersant operations, including planes, personnel, and monitoring, and dispersant chemicals. [9]Wildlife rescue, treatment, and rehabilitation. [10]This sub-total does not include shoreline cleanup operations or disposal of on-water or on-shore collected oil and debris.

Table 20: Estimated Total Response Costs: Strait of Juan de Fuca Scenarios (Costs in 1,000 dollars)								
Scenario	**Percentile Run**	**Non-Shore/Disp TOTAL**	**Shoreline**		**Disposal**		**TOTAL**	
			Min	**Max**	**Min**	**Max**	**Min**	**Max**
S1-Bunk-N	**5th**	$13,860	$5,922	$5,922	$6,562	$6,562	**$26,344**	**$26,344**
	50th	$14,112	$5,219	$5,219	$9,463	$9,463	**$28,794**	**$28,794**
	95th	$14,028	$5,851	$5,851	$6,308	$6,308	**$26,187**	**$26,187**
	Mean	$14,000	$5,664	$5,664	$7,444	$7,444	**$27,108**	**$27,108**
	Mean + 2SD	$14,148	$6,438	$6,438	$9,468	$9,468	**$28,796**	**$28,796**
	Mean - 2SD	$13,852	$4,890	$4,890	$5,421	$5,421	**$25,420**	**$25,420**
S1-Bunk -R-Fed	**5th**	$21,860	$0	$5,034	$4,958	$5,577	**$26,818**	**$32,471**
	50th	$22,257	$1,329	$4,436	$7,144	$8,043	**$30,731**	**$34,736**
	95th	$22,401	$3,378	$4,973	$8,470	$5,362	**$34,249**	**$32,736**
	Mean	$22,173	$1,569	$4,814	$6,858	$6,328	**$30,599**	**$33,315**
	Mean + 2SD	$22,496	$4,972	$5,472	$8,906	$8,048	**$34,892**	**$34,745**
	Mean - 2SD	$21,849	$0	$4,156	$4,810	$4,608	**$26,307**	**$31,885**
S1-Bunk -R-ST	**5th**	$22,090	$0	$5,034	$4,908	$5,577	**$26,998**	**$32,701**
	50th	$22,538	$1,242	$4,436	$7,095	$8,043	**$30,875**	**$35,017**
	95th	$22,646	$3,443	$4,973	$8,549	$5,362	**$34,639**	**$32,981**
	Mean	$22,425	$1,508	$4,814	$6,851	$6,328	**$30,837**	**$33,567**
	Mean + 2SD	$22,765	$3,764	$5,472	$8,967	$8,048	**$35,249**	**$35,026**
	Mean - 2SD	$22,084	$0	$4,156	$4,734	$4,608	**$26,425**	**$32,107**
S1-Bunk -R-3	**5th**	$22,338	$0	$5,034	$5,125	$5,577	**$27,463**	**$32,949**
	50th	$22,702	$644	$4,436	$6,247	$8,043	**$29,593**	**$35,181**
	95th	$22,790	$2,875	$4,973	$8,043	$5,362	**$33,708**	**$33,125**
	Mean	$22,610	$1,173	$4,814	$6,472	$6,328	**$30,255**	**$33,752**
	Mean + 2SD	$22,887	$4,190	$5,472	$8,171	$8,048	**$33,920**	**$35,185**
	Mean - 2SD	$22,333	$0	$4,156	$4,772	$4,608	**$26,590**	**$32,319**
S1-Bunk-R-ISB	**5th**	$20,065	$0	$5,034	$4,968	$5,577	**$25,033**	**$30,676**
	50th	$20,516	$1,472	$4,436	$6,351	$8,043	**$28,339**	**$32,995**
	95th	$20,760	$0	$4,973	$5,079	$5,362	**$25,839**	**$31,095**
	Mean	$20,447	$491	$4,814	$5,466	$6,328	**$26,404**	**$31,589**
	Mean + 2SD	$20,854	$2,190	$5,472	$6,353	$8,048	**$28,394**	**$33,016**
	Mean - 2SD	$20,040	$0	$4,156	$4,579	$4,608	**$24,414**	**$30,162**
S1-Dies-N	**5th**	$23,252	$1,718	$1,718	$4,590	$4,590	**$29,560**	**$29,560**
	50th	$23,130	$2,376	$2,376	$5,632	$5,632	**$31,138**	**$31,138**
	95th	$23,372	$1,668	$1,668	$9,068	$9,068	**$34,108**	**$34,108**
	Mean	$23,251	$1,527	$1,527	$6,430	$6,430	**$31,602**	**$31,602**
	Mean + 2SD	$23,391	$2,104	$2,104	$9,136	$9,136	**$34,268**	**$34,269**
	Mean - 2SD	$23,112	$950	$950	$3,724	$3,725	**$28,936**	**$28,936**

Table 20: Estimated Total Response Costs: Strait of Juan de Fuca Scenarios (Costs in 1,000 dollars) *(continued)*

Scenario	Percentile Run	Non-Shore/Disp TOTAL	Shoreline		Disposal		TOTAL	
			Min	Max	Min	Max	Min	Max
S1- Dies -R-Fed	**5th**	$31,359	$24	$1,460	$10,570	$3,902	**$41,953**	**$36,721**
	50th	$27,143	$501	$2,020	$10,610	$4,787	**$38,254**	**$33,950**
	95th	$30,270	$269	$1,418	$10,612	$7,708	**$41,151**	**$39,396**
	Mean	$29,591	$265	$1,298	$10,597	$5,466	**$40,453**	**$36,689**
	Mean + 2SD	$32,118	$742	$1,788	$10,625	$7,766	**$42,700**	**$39,833**
	Mean - 2SD	$27,064	$0	$808	$10,570	$3,166	**$38,206**	**$33,545**
S1- Dies -R-ST	**5th**	$33,162	$14	$1,460	$10,883	$3,902	**$44,059**	**$38,524**
	50th	$27,743	$99	$2,020	$12,408	$4,787	**$40,250**	**$34,550**
	95th	$32,150	$233	$1,418	$9,533	$7,708	**$41,916**	**$41,276**
	Mean	$31,018	$99	$1,298	$10,941	$5,466	**$42,075**	**$38,117**
	Mean + 2SD	$34,345	$243	$1,788	$12,602	$7,766	**$44,280**	**$42,021**
	Mean - 2SD	$27,691	$0	$808	$9,280	$3,166	**$39,870**	**$34,212**
S1- Dies -R-3	**5th**	$33,616	$14	$1,460	$11,773	$3,902	**$45,403**	**$38,978**
	50th	$28,352	$105	$2,020	$11,960	$4,787	**$40,417**	**$35,159**
	95th	$35,147	$251	$1,418	$11,163	$7,708	**$46,561**	**$44,273**
	Mean	$32,372	$363	$1,298	$11,632	$5,466	**$44,127**	**$39,470**
	Mean + 2SD	$36,487	$120	$1,788	$12,113	$7,766	**$47,897**	**$44,755**
	Mean - 2SD	$28,256	$0	$808	$11,151	$3,166	**$40,357**	**$34,185**
S2- Crud-N	**5th**	$28,091	$5,112	$5,112	$16,165	$16,165	**$49,368**	**$49,368**
	50th	$27,973	$3,013	$3,013	$11,744	$11,744	**$42,730**	**$42,730**
	95th	$27,930	$2,739	$2,739	$10,110	$10,110	**$40,779**	**$40,779**
	Mean	$27,998	$6,217	$6,217	$12,673	$12,673	**$44,292**	**$44,292**
	Mean + 2SD	$28,094	$1,298	$1,298	$16,290	$16,290	**$49,491**	**$49,491**
	Mean - 2SD	$27,902	$1,025	$1,025	$9,056	$9,056	**$39,093**	**$39,093**
S2- Crud-R-Fed	**5th**	$43,604	$903	$4,345	$13,364	$13,740	**$57,871**	**$61,689**
	50th	$43,246	$835	$2,561	$14,461	$9,982	**$58,542**	**$55,789**
	95th	$43,882	$1,593	$2,328	$14,592	$8,594	**$60,067**	**$54,804**
	Mean	$43,577	$1,888	$5,285	$14,139	$10,772	**$58,827**	**$57,427**
	Mean + 2SD	$43,945	$560	$1,103	$14,918	$13,847	**$60,126**	**$61,727**
	Mean - 2SD	$43,209	$0	$871	$13,360	$7,698	**$57,527**	**$53,128**
S2- Crud-R-ST	**5th**	$45,999	$14	$4,345	$10,459	$13,740	**$56,472**	**$64,084**
	50th	$45,658	$596	$2,561	$15,150	$9,982	**$61,404**	**$58,201**
	95th	$46,449	$1,572	$2,328	$14,994	$8,594	**$63,015**	**$57,371**
	Mean	$46,035	$1,585	$5,285	$13,534	$10,772	**$60,297**	**$59,885**
	Mean + 2SD	$46,493	$474	$1,103	$16,611	$13,847	**$64,233**	**$64,112**
	Mean - 2SD	$45,577	$0	$871	$10,458	$7,698	**$56,361**	**$55,659**

Table 20: Estimated Total Response Costs: Strait of Juan de Fuca Scenarios (Costs in 1,000 dollars) *(continued)*								
Scenario	**Percentile Run**	**Non-Shore/Disp TOTAL**	**Shoreline**		**Disposal**		**TOTAL**	
			Min	**Max**	**Min**	**Max**	**Min**	**Max**
S2-Crud-R-3	**5th**	$46,354	$1	$4,345	$10,974	$13,740	**$57,329**	**$64,439**
	50th	$46,030	$785	$2,561	$14,759	$9,982	**$61,574**	**$58,573**
	95th	$46,739	$1,586	$2,328	$15,614	$8,594	**$63,939**	**$57,661**
	Mean	$46,374	$1,867	$5,285	$13,782	$10,772	**$60,947**	**$60,224**
	Mean + 2SD	$46,784	$664	$1,103	$16,634	$13,847	**$64,815**	**$64,472**
	Mean - 2SD	$45,964	$0	$871	$10,931	$7,698	**$57,080**	**$55,977**
S2-Crud-R-ISB	**5th**	$45,733	$1	$4,345	$10,364	$13,740	**$56,098**	**$63,818**
	50th	$44,916	$454	$2,561	$14,017	$9,982	**$59,387**	**$57,459**
	95th	$45,755	$1,584	$2,328	$14,922	$8,594	**$62,261**	**$56,677**
	Mean	$45,468	$2,310	$5,285	$13,101	$10,772	**$59,249**	**$59,318**
	Mean + 2SD	$46,020	$815	$1,103	$15,887	$13,847	**$62,810**	**$63,841**
	Mean - 2SD	$44,916	$0	$871	$10,315	$7,698	**$55,688**	**$54,795**
S2-Crud-C-Fed	**5th**	$44,653	$574	$4,345	$10,037	$13,740	**$55,264**	**$62,738**
	50th	$44,774	$568	$2,561	$13,002	$9,982	**$58,344**	**$57,317**
	95th	$45,353	$1,605	$2,328	$14,895	$8,594	**$61,853**	**$56,275**
	Mean	$44,927	$2,110	$5,285	$12,645	$10,772	**$58,487**	**$58,777**
	Mean + 2SD	$45,359	$597	$1,103	$15,472	$13,847	**$62,294**	**$62,784**
	Mean - 2SD	$44,495	$0	$871	$9,817	$7,698	**$54,680**	**$54,770**
S2-Crud-C-ST	**5th**	$44,677	$0	$4,345	$8,267	$13,740	**$52,944**	**$62,762**
	50th	$44,911	$452	$2,561	$13,687	$9,982	**$59,050**	**$57,454**
	95th	$46,273	$1,628	$2,328	$15,484	$8,594	**$63,385**	**$57,195**
	Mean	$45,287	$1,604	$5,285	$12,479	$10,772	**$58,460**	**$59,137**
	Mean + 2SD	$46,282	$493	$1,103	$16,818	$13,847	**$64,517**	**$62,765**
	Mean - 2SD	$44,292	$0	$871	$8,141	$7,698	**$52,403**	**$55,509**
S2-Crud-C-3	**5th**	$44,871	$0	$4,345	$9,363	$13,740	**$54,234**	**$62,956**
	50th	$44,633	$355	$2,561	$12,623	$9,982	**$57,611**	**$57,176**
	95th	$45,871	$1,519	$2,328	$15,104	$8,594	**$62,494**	**$56,793**
	Mean	$45,125	$2,214	$5,285	$12,363	$10,772	**$58,113**	**$58,975**
	Mean + 2SD	$45,884	$795	$1,103	$15,688	$13,847	**$62,908**	**$62,962**
	Mean - 2SD	$44,366	$0	$871	$9,039	$7,698	**$53,318**	**$54,988**

Table 21: Shoreline Impact and Bbl Oil Removed: Strait of Juan de Fuca Scenarios				
Scenario	**Percentile**	**Shoreline Impact (m^2)**	**Bbl Oil Removed**	**% Removed Offshore**
S1-Bunk- N	**5th**	43,745	0	0%
	50th	63,084	0	0%
	95th	42,056	0	0%
	MEAN	49,628	0	0%
	MEAN + 2SD	73,012	0	0%
	MEAN - SD	27,461	0	0%
S1-Bunk-R-Fed	**5th**	0	22,954	92%
	50th	16,146	21,863	87%
	95th	27,036	20,440	82%
	MEAN	14,394	21,752	87%
	MEAN + 2SD	41,600	24,274	97%
	MEAN - SD	0	19,230	77%
S1-Bunk-R-ST	**5th**	0	22,720	91%
	50th	15,771	21,894	88%
	95th	28,163	20,023	80%
	MEAN	14,793	21,247	85%
	MEAN + 2SD	37,591	26,048	104%
	MEAN - SD	0	16,447	66%
S1-Bunk-R-3	**5th**	0	23,729	95%
	50th	8,261	23,185	93%
	95th	23,281	21,069	84%
	MEAN	10,514	22,661	91%
	MEAN + 2SD	34,133	25,472	102%
	MEAN - SD	0	19,851	79%
S1-Bunk-R-ISB	**5th**	0	23,002	92%
	50th	10,514	22,100	88%
	95th	0	23,516	94%
	MEAN	3,505	22,873	91%
	MEAN + 2SD	15,645	24,306	97%
	MEAN - SD	0	21,439	86%
S1-Dies-N	**5th**	30,603	0	0%
	50th	37,549	0	0%
	95th	60,455	0	0%
	MEAN	42,869	0	0%
	MEAN + 2SD	83,322	0	0%
	MEAN - SD	5,485	0	0%
S1-Dies-R-Fed	**5th**	5,445	45,156	69%
	50th	12,767	40,255	62%
	95th	62,708	5,584	9%
	MEAN	26,973	30,332	47%
	MEAN + 2SD	90,932	73,475	113%
	MEAN - SD	0	0	0%

Table 21: Shoreline Impact and Bbl Oil Removed: Strait of Juan de Fuca Scenarios				
Scenario	**Percentile**	**Shoreline Impact (m^2)**	**Bbl Oil Removed**	**%Recovered Offshore**
S1-Dies-R-ST	**5th**	3,380	48,039	74%
	50th	16,147	46,231	71%
	95th	53,508	6,974	11%
	MEAN	19,955	31,340	48%
	MEAN + 2SD	52,067	57,813	89%
	MEAN - SD	0	4,866	7%
S1-Dies-R-3	**5th**	3,943	51,769	80%
	50th	8,824	49,245	76%
	95th	57,076	12,044	19%
	MEAN	23,281	37,686	58%
	MEAN + 2SD	82,059	82,171	126%
	MEAN - SD	0	0	0%
S2-Crud-N	**5th**	107,767	0	0%
	50th	78,291	0	0%
	95th	67,402	0	0%
	MEAN	84,487	0	0%
	MEAN + 2SD	126,393	0	0%
	MEAN - SD	42,581	0	0%
S2-Crud-R-Fed	**5th**	29,477	41,399	64%
	50th	35,672	42,179	65%
	95th	40,930	39,131	60%
	MEAN	27,749	42,130	65%
	MEAN + 2SD	56,322	46,477	72%
	MEAN - SD	7,612	37,782	58%
S2-Crud-R-ST	**5th**	1,690	47,247	73%
	50th	36,986	44,455	68%
	95th	42,055	40,214	62%
	MEAN	23,365	43,627	67%
	MEAN + 2SD	61,812	53,812	83%
	MEAN - SD	0	33,443	51%
S2-Crud-R-3	**5th**	188	50,676	78%
	50th	35,297	43,819	67%
	95th	43,183	42,300	65%
	MEAN	18,888	46,706	72%
	MEAN + 2SD	58,326	53,712	83%
	MEAN - SD	0	39,699	61%
S2-Crud-R-ISB	**5th**	188	47,851	74%
	50th	28,913	44,815	69%
	95th	41,680	40,138	62%
	MEAN	23,594	44,268	68%
	MEAN + 2SD	72,594	52,039	80%
	MEAN - SD	0	36,497	56%

Table 21: Shoreline Impact and Bbl Oil Removed: Strait of Juan de Fuca Scenarios *(continued)*				
Scenario	**Percentile**	**Shoreline Impact (m^2)**	**Bbl Oil Removed**	**% Removed Offshore**
S2-Crud-C-Fed	**5th**	19,713	32,778	50%
	50th	26,660	41,680	64%
	95th	43,370	38,838	60%
	MEAN	29,914	37,765	58%
	MEAN + 2SD	55,179	46,859	72%
	MEAN - SD	5,054	28,672	44%
S2-Crud-C-ST	**5th**	0	38,271	59%
	50th	29,101	43,159	66%
	95th	46,186	39,613	61%
	MEAN	23,418	41,452	64%
	MEAN + 2SD	63,792	51,397	79%
	MEAN - SD	0	31,507	48%
S2-Crud-C-3	**5th**	0	43,349	67%
	50th	21,028	43,839	67%
	95th	40,554	41,764	64%
	MEAN	20,527	42,984	66%
	MEAN + 2SD	64,015	45,153	69%
	MEAN - SD	0	40,815	63%

Outer Coast Scenarios
Estimated cost results for the Outer Coast scenarios are shown in Tables 22 – 23. Shoreline impacts and oil removal are shown in Table 24.

Table 22: Modeled Oil Spill Response Costs Excluding Shoreline Response Costs and Disposal Costs: Outer Coast Scenarios (Costs in 1,000 dollars)

Scenario	Per-centile	Mobilize[1]	Boom[2]	Mech[3]	Mgt + Monitor[4]	Salvage[5]	Decon[6]	ISB[7]	Disp Ops[8]	Wild-life[9]	Non-Shoreline Non-Disposal TOTAL[10]
OC-Crud-N	**5th**	$500	$13,600	$60	$2,000	$8,000	$500	0	0	$3,000	**$28,160**
	50th	$500	$13,600	$60	$2,345	$8,000	$500	0	0	$3,000	**$28,505**
	95th	$500	$13,600	$60	$2,947	$8,000	$500	0	0	$3,000	**$29,107**
OC-Crud-R-Fed	**5th**	$500	$13,600	$11,890	$8,550	$8,000	$0	0	0	$3,000	**$46,040**
	50th	$500	$13,600	$11,890	$8,742	$8,000	$4,159	0	0	$3,000	**$50,391**
	95th	$500	$13,600	$11,890	$8,707	$8,000	$4,068	0	0	$3,000	**$50,265**
OC-Crud-R-ST	**5th**	$500	$13,600	$8,122	$8,000	$8,000	$0	0	0	$3,000	**$41,722**
	50th	$500	$13,600	$16,762	$8,696	$8,000	$4,222	0	0	$3,000	**$55,280**
	95th	$500	$13,600	$16,762	$8,690	$8,000	$4,172	0	0	$3,000	**$55,224**
OC-Crud-R-3	**5th**	$500	$13,600	$5,945	$8,000	$8,000	$0	0	0	$3,000	**$39,545**
	50th	$500	$13,600	$23,916	$8,685	$8,000	$4,326	0	0	$3,000	**$62,527**
	95th	$500	$13,600	$23,916	$8,644	$8,000	$4,307	0	0	$3,000	**$62,467**
OC-Crud-R-ISB	**5th**	$500	$13,600	$7,048	$4,000	$8,000	$0	$720	0	$3,000	**$37,368**
	50th	$500	$13,600	$10,273	$4,743	$8,000	$4,282	$720	0	$3,000	**$45,618**
	95th	$500	$13,600	$10,273	$4,681	$8,000	$4,215	$720	0	$3,000	**$45,489**
OC-Crud-C-Fed	**5th**	$500	$13,600	$0	$4,000	$8,000	$0	0	$3,000	$3,000	**$32,600**
	50th	$500	$13,600	$3,418	$4,763	$8,000	$3,729	0	$3,000	$3,000	**$40,510**
	95th	$500	$13,600	$3,418	$4,687	$8,000	$4,016	0	$3,000	$3,000	**$40,721**
OC-Crud-C-ST	**5th**	$500	$13,600	$1,103	$4,000	$8,000	$0	0	$3,000	$3,000	**$33,703**
	50th	$500	$13,600	$6,037	$4,778	$8,000	$3,805	0	$3,000	$3,000	**$43,220**
	95th	$500	$13,600	$6,037	$4,701	$8,000	$4,093	0	$3,000	$3,000	**$43,431**
OC-Crud-C-3	**5th**	$500	$13,600	$1,107	$4,000	$8,000	$0	0	$3,000	$3,000	**$33,707**
	50th	$500	$13,600	$5,719	$4,674	$8,000	$3,850	0	$3,000	$3,000	**$42,843**
	95th	$500	$13,600	$6,041	$4,693	$8,000	$4,261	0	$3,000	$3,000	**$43,595**

[1]Initial mobilization of resources, including equipment and personnel, at first notification of major spill. These costs are charged to responsible party regardless of whether the equipment/personnel are ever deployed. [2]Protective booming of sensitive resources based on Geographic Response Plans associated with Northwest Area Contingency Plan. [3]On-water mechanical containment and recovery operations, including equipment and personnel. [4]Spill management, qualified individual services, and other responsible-party associated costs, and government monitoring costs. [5]Salvage or source control to stop leak of oil, lighter vessel, and protect public safety. [6]Decontamination of oiled equipment, worker clothing, *etc.* [7]*In-situ* burning operations, including planes, ignition equipment and fuel, personnel, and monitoring of airborne particulates. [8]Dispersant operations, including planes, personnel, and monitoring, and dispersant chemicals. [9]Wildlife rescue, treatment, and rehabilitation. [10]This sub-total does not include shoreline cleanup operations or disposal of on-water or on-shore collected oil and debris.

Table 23: Estimated Total Response Costs: Outer Coast Scenarios (Costs in 1,000 dollars)								
Scenario	**Percentile Run**	**Non-Shore/ Disp TOTAL**	**Shoreline**		**Disposal**		**TOTAL**	
			Min	**Max**	**Min**	**Max**	**Min**	**Max**
OC-Crud-N	**5th**	$28,160	$0	$0	$0	$0	**$28,160**	**$28,160**
	50th	$28,505	$3,122	$3,122	$12,951	$12,951	**$44,578**	**$44,578**
	95th	$29,107	$8,262	$8,262	$35,518	$35,518	**$72,887**	**$72,887**
	Mean	$28,591	$3,544	$3,544	$16,156	$16,156	**$48,542**	**$48,542**
	Mean + 2SD	$29,144	$8,589	$8,589	$36,912	$36,912	**$74,667**	**$74,667**
	Mean - 2SD	$28,037	$0	$0	$0	$0	**$22,416**	**$22,416**
OC-Crud-R-Fed	**5th**	$46,040	$0	$0	$1,448	$0	**$47,488**	**$46,040**
	50th	$50,391	$709	$2,654	$16,166	$11,008	**$67,266**	**$64,053**
	95th	$50,265	$984	$7,023	$14,668	$30,190	**$65,917**	**$87,478**
	Mean	$48,899	$565	$3,012	$10,278	$13,733	**$60,224**	**$65,857**
	Mean + 2SD	$51,758	$1,580	$7,301	$20,592	$31,375	**$72,983**	**$89,849**
	Mean - 2SD	$46,039	$0	$0	$0	$0	**$47,464**	**$41,865**
OC-Crud-R-ST	**5th**	$41,722	$0	$0	$0	$0	**$41,722**	**$41,722**
	50th	$55,280	$557	$2,654	$14,606	$11,008	**$70,443**	**$68,942**
	95th	$55,224	$875	$7,023	$14,271	$30,190	**$70,370**	**$92,437**
	Mean	$50,742	$778	$3,012	$9,626	$13,733	**$60,845**	**$67,700**
	Mean + 2SD	$59,762	$2,198	$7,301	$19,253	$31,375	**$79,968**	**$97,007**
	Mean - 2SD	$41,722	$0	$0	$0	$0	**$41,722**	**$38,394**
OC-Crud-R-3	**5th**	$39,545	$0	$0	$3,083	$0	**$42,628**	**$39,545**
	50th	$62,527	$596	$2,654	$16,470	$11,008	**$79,593**	**$76,189**
	95th	$62,467	$868	$7,023	$14,901	$30,190	**$78,236**	**$99,680**
	Mean	$54,846	$488	$3,012	$10,457	$13,733	**$66,819**	**$71,805**
	Mean + 2SD	$70,148	$1,221	$7,301	$20,953	$31,375	**$91,023**	**$106,799**
	Mean - 2SD	$39,545	$0	$0	$0	$0	**$42,615**	**$36,810**
OC-Crud-R-ISB	**5th**	$37,368	$0	$0	$2,887	$0	**$40,255**	**$37,368**
	50th	$45,618	$633	$2,654	$16,489	$11,008	**$62,740**	**$59,280**
	95th	$45,489	$859	$7,023	$14,025	$30,190	**$60,373**	**$82,702**
	Mean	$42,825	$497	$3,012	$10,171	$13,733	**$54,456**	**$59,783**
	Mean + 2SD	$48,283	$1,388	$7,301	$20,442	$31,375	**$68,723**	**$85,962**
	Mean - 2SD	$37,367	$0	$0	$0	$0	**$40,189**	**$33,605**
OC-Crud-C-Fed	**5th**	$32,600	$0	$0	$1,363	$0	**$33,963**	**$32,600**
	50th	$40,510	$695	$2,654	$16,029	$11,008	**$57,234**	**$54,172**
	95th	$40,721	$943	$7,023	$13,821	$30,190	**$55,485**	**$77,934**
	Mean	$37,944	$546	$3,012	$9,950	$13,733	**$48,894**	**$54,902**
	Mean + 2SD	$43,289	$1,524	$7,301	$19,981	$31,375	**$63,859**	**$81,086**
	Mean - 2SD	$32,599	$0	$0	$0	$0	**$33,929**	**$28,718**
OC-Crud-C-ST	**5th**	$33,703	$0	$0	$0	$0	**$33,703**	**$33,703**
	50th	$43,220	$714	$2,654	$16,760	$11,008	**$60,694**	**$56,882**
	95th	$43,431	$859	$7,023	$14,497	$30,190	**$58,787**	**$80,644**
	Mean	$40,118	$764	$3,012	$10,419	$13,733	**$51,061**	**$57,076**
	Mean + 2SD	$46,534	$2,247	$7,301	$20,920	$31,375	**$68,455**	**$84,178**
	Mean - 2SD	$33,702	$0	$0	$0	$0	**$33,668**	**$29,974**
OC-Crud-C-3	**5th**	$33,707	$0	$0	$2,900	$0	**$36,607**	**$33,707**
	50th	$42,843	$583	$2,654	$15,046	$11,008	**$58,472**	**$56,505**
	95th	$43,595	$807	$7,023	$14,577	$30,190	**$58,979**	**$80,808**
	Mean	$40,048	$463	$3,012	$9,874	$13,733	**$51,353**	**$57,007**
	Mean + 2SD	$46,405	$1,297	$7,301	$19,752	$31,375	**$66,101**	**$84,205**
	Mean - 2SD	$33,692	$0	$0	$0	$0	**$36,604**	**$29,808**

Table 24: Shoreline Impact and Bbl Oil Removed: Outer Coast Scenarios				
Scenario	**Percentile**	**Shoreline Impact (m^2)**	**Bbl Oil Removed**	**% Removed Offshore**
OC-Crud-N	**5^{th}**	0	0	0%
	50^{th}	86,343	0	0%
	95^{th}	236,789	0	0%
	MEAN	97,116	0	0%
	MEAN + 2SD	239,988	0	0%
	MEAN - SD	0	0	0%
OC-Crud-R-Fed	**5^{th}**	0	6,702	10%
	50^{th}	47,885	41,591	64%
	95^{th}	39,213	40,677	63%
	MEAN	29,033	29,656	46%
	MEAN + 2SD	87,876	69,426	107%
	MEAN - SD	0	0	0%
OC-Crud-R-ST	**5^{th}**	0	0	0%
	50^{th}	36,574	42,223	65%
	95^{th}	35,066	41,718	64%
	MEAN	32,875	42,239	65%
	MEAN + 2SD	95,639	55,169	85%
	MEAN - SD	0	29,310	45%
OC-Crud-R-3	**5^{th}**	0	14,274	22%
	50^{th}	47,508	43,257	67%
	95^{th}	37,327	43,066	66%
	MEAN	28,278	33,532	52%
	MEAN + 2SD	76,105	66,890	103%
	MEAN - SD	0	175	0%
OC-Crud-R-ISB	**5^{th}**	0	13,368	21%
	50^{th}	48,262	42,824	66%
	95^{th}	32,804	42,151	65%
	MEAN	27,022	32,781	50%
	MEAN + 2SD	86,989	66,412	102%
	MEAN - SD	0	0	0%

Table 24: Shoreline Impact and Bbl Oil Removed: Outer Coast Scenarios				
Scenario	**Percentile**	**Shoreline Impact (m^2)**	**Bbl Oil Removed**	**% Removed Offshore**
OC-Crud-C-Fed	**5th**	0	6,311	10%
	50th	53,164	37,289	57%
	95th	34,312	40,157	62%
	MEAN	29,159	27,919	43%
	MEAN + 2SD	96,169	44,616	69%
	MEAN - SD	0	11,222	17%
OC-Crud-C-ST	**5th**	0	0	0%
	50th	56,934	38,053	59%
	95th	37,704	40,931	63%
	MEAN	32,852	38,570	59%
	MEAN + 2SD	98,342	49,868	77%
	MEAN - SD	0	27,272	42%
OC-Crud-C-3	**5th**	0	13,427	21%
	50th	44,869	38,499	59%
	95th	35,819	42,613	66%
	MEAN	26,896	31,513	48%
	MEAN + 2SD	81,213	63,107	97%
	MEAN - SD	0	0	0%

Columbia River Scenarios

Estimated cost results for the Columbia River scenarios are shown in Tables 25 – 26. Shoreline impacts and oil removal are shown in Table 27.

Table 25 Modeled Oil Spill Response Costs Excluding Shoreline Response Costs and Disposal Costs: Columbia River Scenarios (Costs in 1,000 dollars)

Scenario	Per-centile	Mobilize[1]	Boom[2]	Mech[3]	Mgt + Monitor[4]	Salvage[5]	Decon[6]	ISB[7]	Disp Ops[8]	Wild-life[9]	Non-Shoreline Non-Disposal TOTAL[10]
C1-Bunk-N	5th	$500	$6,800	$60	$2,543	$3,000	$500	0	0	$1,000	$14,403
	50th	$500	$6,800	$60	$2,651	$3,000	$500	0	0	$1,000	$14,511
	95th	$500	$6,800	$60	$2,655	$3,000	$500	0	0	$1,000	$14,515
C1-Bunk-R-Fed	5th	$500	$6,800	$3,040	$4,712	$3,000	$3,907	0	0	$1,000	$22,959
	50th	$500	$6,800	$2,840	$4,847	$3,000	$2,953	0	0	$1,000	$21,940
	95th	$500	$6,800	$2,840	$4,862	$3,000	$2,990	0	0	$1,000	$21,992
C1-Bunk-R-ST	5th	$500	$6,800	$3,766	$4,602	$3,000	$4,110	0	0	$1,000	$23,778
	50th	$500	$6,800	$3,988	$4,937	$3,000	$3,065	0	0	$1,000	$23,290
	95th	$500	$6,800	$3,666	$4,865	$3,000	$3,059	0	0	$1,000	$22,890
C1-Bunk-R-3	5th	$500	$6,800	$4,153	$4,647	$3,000	$4,124	0	0	$1,000	$24,224
	50th	$500	$6,800	$3,882	$4,729	$3,000	$3,440	0	0	$1,000	$23,351
	95th	$500	$6,800	$4,053	$4,828	$3,000	$3,423	0	0	$1,000	$23,604
C2-Bunk-N	5th	$500	$6,800	$60	$2,301	$3,000	$500	0	0	$1,000	$14,161
	50th	$500	$6,800	$60	$2,199	$3,000	$500	0	0	$1,000	$14,059
	95th	$500	$6,800	$60	$2,276	$3,000	$500	0	0	$1,000	$14,136
C2-Bunk-R-Fed	5th	$500	$6,800	$2,840	$4,573	$3,000	$3,373	0	0	$1,000	$22,086
	50th	$500	$6,800	$2,840	$4,633	$3,000	$3,892	0	0	$1,000	$22,665
	95th	$500	$6,800	$3,040	$4,792	$3,000	$3,812	0	0	$1,000	$22,944
C2-Bunk-R-ST	5th	$500	$6,800	$3,988	$4,811	$3,000	$4,259	0	0	$1,000	$24,358
	50th	$500	$6,800	$3,988	$4,744	$3,000	$3,895	0	0	$1,000	$23,927
	95th	$500	$6,800	$3,606	$4,605	$3,000	$3,349	0	0	$1,000	$22,860
C2-Bunk-R-3	5th	$500	$6,800	$4,734	$4,940	$3,000	$3,178	0	0	$1,000	$24,152
	50th	$500	$6,800	$4,053	$4,626	$3,000	$4,025	0	0	$1,000	$24,004
	95th	$500	$6,800	$4,494	$4,795	$3,000	$3,674	0	0	$1,000	$24,263

[1]Initial mobilization of resources, including equipment and personnel, at first notification of major spill. These costs are charged to responsible party regardless of whether the equipment/personnel are ever deployed. [2]Protective booming of sensitive resources based on Geographic Response Plans associated with Northwest Area Contingency Plan. [3]On-water mechanical containment and recovery operations, including equipment and personnel. [4]Spill management, qualified individual services, and other responsible-party associated costs, and government monitoring costs. [5]Salvage or source control to stop leak of oil, lighter vessel, and protect public safety. [6]Decontamination of oiled equipment, worker clothing, *etc.* [7]*In-situ* burning operations, including planes, ignition equipment and fuel, personnel, and monitoring of airborne particulates. [8]Dispersant operations, including planes, personnel, and monitoring, and dispersant chemicals. [9]Wildlife rescue, treatment, and rehabilitation. [10]This sub-total does not include shoreline cleanup operations or disposal of on-water or on-shore collected oil and debris.

Table 26: Estimated Total Response Costs: Columbia River Scenarios (Costs in 1,000 dollars)								
Scenario	**Percentile Run**	**Non-Shore/Disp TOTAL**	**Shoreline**		**Disposal**		**TOTAL**	
			Min	**Max**	**Min**	**Max**	**Min**	**Max**
C1-Bunk-N	**5th**	$14,403	$14,663	$14,663	$20,360	$20,360	**$49,426**	**$49,426**
	50th	$14,511	$17,473	$17,473	$24,426	$24,426	**$56,410**	**$56,410**
	95th	$14,515	$16,406	$16,406	$24,577	$24,577	**$55,498**	**$55,498**
	Mean	$14,476	$16,180	$16,180	$23,121	$23,121	**$53,778**	**$53,778**
	Mean + 2SD	$14,550	$19,016	$19,016	$25,883	$25,883	**$58,162**	**$58,162**
	Mean - 2SD	$14,403	$13,344	$13,344	$20,359	$20,359	**$49,394**	**$49,394**
C1-Bunk-R-Fed	**5th**	$22,959	$2,504	$12,464	$8,237	$17,306	**$33,700**	**$52,729**
	50th	$21,940	$7,778	$14,852	$14,310	$20,762	**$44,028**	**$57,554**
	95th	$21,992	$7,220	$13,945	$14,928	$20,890	**$44,140**	**$56,827**
	Mean	$22,297	$5,463	$13,753	$12,492	$19,653	**$40,623**	**$55,704**
	Mean + 2SD	$22,960	$10,422	$16,164	$16,761	$22,001	**$47,546**	**$58,707**
	Mean - 2SD	$21,634	$505	$11,342	$8,222	$17,305	**$33,700**	**$52,700**
C1-Bunk-R-ST	**5th**	$23,778	$1,758	$12,464	$6,397	$17,306	**$31,933**	**$53,548**
	50th	$23,290	$7,282	$14,852	$13,703	$20,762	**$44,275**	**$58,904**
	95th	$22,890	$7,338	$13,945	$15,103	$20,890	**$45,331**	**$57,725**
	Mean	$23,319	$2,362	$13,753	$11,734	$19,653	**$40,513**	**$56,726**
	Mean + 2SD	$23,833	$6,774	$16,164	$17,133	$22,001	**$49,115**	**$59,976**
	Mean - 2SD	$22,806	$0	$11,342	$6,336	$17,305	**$31,911**	**$53,476**
C1-Bunk-R-3	**5th**	$24,224	$2,255	$12,464	$8,094	$17,306	**$34,573**	**$53,994**
	50th	$23,351	$5,893	$14,852	$12,501	$20,762	**$41,745**	**$58,965**
	95th	$23,604	$6,440	$13,945	$14,141	$20,890	**$44,185**	**$58,439**
	Mean	$23,726	$4,686	$13,753	$11,579	$19,653	**$40,168**	**$57,133**
	Mean + 2SD	$24,245	$8,468	$16,164	$15,190	$22,001	**$45,937**	**$60,286**
	Mean - 2SD	$23,208	$905	$11,342	$7,968	$17,305	**$34,398**	**$53,979**

Table 26: Estimated Total Response Costs: Columbia River Scenarios (Costs in 1,000 dollars) *(continued)*								
Scenario	**Percentile Run**	**Non-Shore/Disp TOTAL**	**Shoreline**		**Disposal**		**TOTAL**	
			Min	**Max**	**Min**	**Max**	**Min**	**Max**
C2-Bunk-N	**5th**	$14,161	$6,827	$6,827	$11,297	$11,297	**$32,285**	**$32,285**
	50th	$14,059	$4,715	$4,715	$7,481	$7,481	**$26,255**	**$26,255**
	95th	$14,136	$6,526	$6,526	$10,368	$10,368	**$31,030**	**$31,030**
	Mean	$14,119	$6,022	$6,022	$9,715	$9,715	**$29,857**	**$29,857**
	Mean + 2SD	$14,180	$8,307	$8,307	$12,013	$12,013	**$33,530**	**$33,530**
	Mean - 2SD	$14,057	$3,738	$3,738	$7,418	$7,418	**$26,183**	**$26,183**
C2-Bunk-R-Fed	**5th**	$22,086	$3,322	$5,803	$4,522	$9,602	**$29,930**	**$37,491**
	50th	$22,665	$1,758	$4,008	$7,316	$6,359	**$31,739**	**$33,032**
	95th	$22,944	$2,539	$5,547	$11,146	$8,813	**$36,629**	**$37,304**
	Mean	$22,565	$1,760	$5,119	$7,661	$8,258	**$32,766**	**$35,942**
	Mean + 2SD	$23,070	$3,930	$7,061	$11,501	$10,211	**$36,768**	**$38,855**
	Mean - 2SD	$22,060	$0	$3,177	$3,821	$6,305	**$28,764**	**$33,030**
C2-Bunk-R-ST	**5th**	$24,358	$583	$5,803	$10,248	$9,602	**$35,189**	**$39,763**
	50th	$23,927	$1,709	$4,008	$7,345	$6,359	**$32,981**	**$34,294**
	95th	$22,860	$4,522	$5,547	$7,759	$8,813	**$35,141**	**$37,220**
	Mean	$23,715	$1,952	$5,119	$8,451	$8,258	**$34,437**	**$37,092**
	Mean + 2SD	$24,605	$4,230	$7,061	$10,264	$10,211	**$35,893**	**$40,253**
	Mean - 2SD	$22,825	$0	$3,177	$6,638	$6,305	**$32,981**	**$33,932**
C2-Bunk-R-3	**5th**	$24,152	$3,806	$5,803	$9,809	$9,602	**$37,767**	**$39,557**
	50th	$24,004	$1,552	$4,008	$7,183	$6,359	**$32,739**	**$34,371**
	95th	$24,263	$2,994	$5,547	$9,039	$8,813	**$36,296**	**$38,623**
	Mean	$24,140	$1,984	$5,119	$8,677	$8,258	**$35,601**	**$37,517**
	Mean + 2SD	$24,290	$4,571	$7,061	$10,236	$10,211	**$38,586**	**$40,709**
	Mean - 2SD	$23,990	$0	$3,177	$7,118	$6,305	**$32,616**	**$34,325**

Table 27: Shoreline Impact and Bbl Oil Removed: Columbia River Scenarios				
Scenario	**Percentile**	**Shoreline Impact (m^2)**	**Bbl Oil Removed**	**$ Recovered Offshore**
C1-Bunk-N	**5th**	135,735	0	0%
	50th	162,843	0	0%
	95th	163,844	0	0%
	MEAN	154,144	0	0%
	MEAN + 2SD	193,971	0	0%
	MEAN - SD	114,317	0	0%
C1-Bunk-R-Fed	**5th**	26,778	19,537	78%
	50th	74,141	14,763	59%
	95th	77,990	14,951	60%
	MEAN	57,154	16,865	67%
	MEAN + 2SD	105,668	21,629	87%
	MEAN - SD	9,102	12,100	48%
C1-Bunk-R-ST	**5th**	13,054	20,549	82%
	50th	69,288	15,325	61%
	95th	78,660	15,294	61%
	MEAN	53,667	19,048	76%
	MEAN + 2SD	94,640	24,591	98%
	MEAN - SD	12,695	13,505	54%
C1-Bunk-R-3	**5th**	24,268	20,619	82%
	50th	58,576	17,198	69%
	95th	69,623	17,117	68%
	MEAN	49,288	18,383	74%
	MEAN + 2SD	88,971	21,660	87%
	MEAN - SD	9,993	15,106	60%

Table 27: Shoreline Impact and Bbl Oil Removed: Columbia River Scenarios *(continued)*				
Scenario	**Percentile**	**Shoreline Impact (m^2)**	**Bbl Oil Removed**	**% Removed Offshore**
C2-Bunk-N	**5th**	75,314	0	0%
	50th	49,874	0	0%
	95th	69,122	0	0%
	MEAN	64,770	0	0%
	MEAN + 2SD	91,542	0	0%
	MEAN - SD	39,352	0	0%
C2-Bunk-R-Fed	**5th**	5,858	16,866	67%
	50th	20,753	19,459	78%
	95th	46,862	19,061	76%
	MEAN	21,689	19,671	79%
	MEAN + 2SD	45,874	23,269	93%
	MEAN - SD	0	16,073	64%
C2-Bunk-R-ST	**5th**	37,657	21,295	85%
	50th	20,921	19,477	78%
	95th	27,616	16,745	67%
	MEAN	19,833	18,236	73%
	MEAN + 2SD	44,844	25,156	101%
	MEAN - SD	0	11,317	45%
C2-Bunk-R-3	**5th**	42,511	15,891	64%
	50th	18,912	20,123	80%
	95th	33,807	18,371	73%
	MEAN	22,817	19,403	78%
	MEAN + 2SD	52,140	24,055	96%
	MEAN - SD	0	14,750	59%

Comparison of Response Capabilities and Response Methods

A comparison between the total modeled shoreline impacts with different response methods and response capabilities is shown in Table 28 (as median and two standard deviations above median) for crude spills. The shore impacts are shown for no on-water response and for theoretically “effective” and “15% effective” offshore mechanical containment and recovery. The corresponding total response costs are shown in Table 29. Analogous results are shown for diesel spills in Tables 30 – 31, and bunker spills in Tables 32 – 33.

Table 28: Comparison of Shoreline Oiling by Response Capability/Method: Crude Spills (1,000 m^2 oiled)

Location	Response Type	No Response	Federal *Effective*[1] *15% Effective*[2]	State *Effective*[1] *15% Effective*[2]	3rd *Effective*[1] *15% Effective*[2]	Comments
San Juan Islands	**None**	350 (620)	-	-	-	Significant reduction impact with effective mech; some reduction with ST and 3
	Mech	-	68 (167) 298 (527)	54 (124) 298 (527)	51 (118) 298 (527)	
	Disp	-	86 (201) 298 (527)	53 (122) 298 (527)	60 (149) 298 (527)	
	ISB	-	-	-	-	
Inner Straits	**None**	291 (573)	-	-	-	Significant reduction impact with effective mech; some reduction with ST, 3, DISP
	Mech	-	54 (143) 247 (487)	41 (114) 247 (487)	36 (92) 247 (487)	
	Disp	-	42 (146) 247 (487)	39 (108) 247 (487)	24 (89) 247 (487)	
	ISB	-	-	-	-	
Str Juan de Fuca	**None**	84 (126)	-	-	-	Significant reduction impact with effective mech; no difference with DISP. Some reduction with ST, 3
	Mech	-	27 (56) 71 (107)	23 (62) 71 (107)	19 (58) 71 (107)	
	Disp	-	30 (55) 71 (107)	23 (64) 71 (107)	24 (73) 84 (126)	
	ISB	-	-	24 (73) 71 (107)	-	
Outer Coast	**None**	97 (240)	-	-	-	Significant reduction impact with effective mech; no difference with DISP. No difference CAPS
	Mech	-	29 (88) 82 (204)	33 (96) 82 (204)	28 (76) 82 (204)	
	Disp	-	29 (96) 82 (204)	33 (98) 82 (204)	27 (81) 82 (204)	
	ISB	-	-	27 (87) 82 (204)	-	

[1]Mean shoreline impact with effective on-water mechanical spill response, as modeled. Mean + 2 standard deviations in parentheses. [2]Mean shoreline impact assuming 15% on-water mechanical spill response.

Table 29: Comparison of Mean Response Costs[1] by Response Capability/Method: Crude Spills (Million Dollars)						
Location	**Response Type**	**No Response**	**Federal** *Effective*[2] *15% Effective*[3]	**State** *Effective*[2] *15% Effective*[3]	**3rd** *Effective*[2] *15% Effective*[3]	**Comments**[4]
San Juan Islands	**None**	$96.5 ($125.2)	-	-	-	No significant difference in CAPS. Potential cost reduction over NR if response effective. No DISP advantage.
	Mech	-	$69.1($78.4) $109.4 ($136.6)	$67.3 ($77.1) $110.4 ($137.7)	$65.9 ($73.9) $110.4 ($137.5)	
	Disp	-	$65.4 ($75.5) $106.6 ($134.1)	$65.7 ($72.6) $107.3 ($134.5)	$63.8 ($71.9) $108.4 ($135.6)	
	ISB	-	-	-	-	
Inner Straits	**None**	$84.6 ($116.9)	-	-	-	No significant difference in CAPS. Slight cost reduction with DISP. Significant cost reduction of all over NR
	Mech	-	$63.5 ($73.4) $91.0 ($117.8)	$63.4 ($73.1) $92.4 ($119.2)	$62.5 ($69.1) $92.5 ($119.3)	
	Disp	-	$56.4 ($65.0) $87.9 ($114.5)	$57.3 ($65.2) $88.9 ($115.8)	$55.6 ($61.7) $89.0 ($115.8)	
	ISB	-	-	-	-	
Str Juan de Fuca	**None**	$44.3 ($49.5)	-	-	-	No significant difference in CAPS. Slight cost increase with DISP. Disposal bbl oil higher.
	Mech	-	$58.8 ($60.1) $57.4 ($61.7)	$63.0 ($64.3) $59.9 ($64.1)	$60.9 ($64.8) $60.2 ($64.4)	
	Disp	-	$58.5 ($62.3) $58.8 ($62.8)	$58.5 ($64.5) $59.1 ($62.8)	$58.1 ($62.9) $59.0 ($63.0)	
	ISB	-	-	$59.2 ($62.8) $59.3 ($63.8)	-	
Outer Coast	**None**	$48.5 ($74.7)	-	-	-	No significant difference in CAPS. Lower costs with NR. Lower costs with DISP.
	Mech	-	$60.2 ($73.0) $65.9 ($89.8)	$60.8 ($80.0) $67.7 ($97.0)	$66.8 ($91.0) $71.8 ($106.8)	
	Disp	-	$48.9 ($63.9) $54.9 ($81.1)	$51.1 ($68.5) $57.1 ($84.2)	$51.4 ($66.1) $57.0 ($84.2)	
	ISB	-	-	$54.5 ($68.7) $59.8 ($86.0)	-	

[1]Mean response (Mean + 2 standard deviations) costs in million dollars (2003$). [2]Mean response costs with effective modeled mechanical response. [3]Mean response costs wiht 15% on-water mechanical spill response. [4]CAPS = response capabilities. NR = "no response" DISP = dispersant; mech = mechanical; ISB = *in-situ* burning.

Table 30: Comparison of Shoreline Oiling by Response Capability/Method: Diesel Spills (1,000 m^2 oiled)						
Location	**Response Type**	**No Response**	**Federal** *Effective*[1] *15% Effective*[2]	**State** *Effective*[1] *15% Effective*[2]	**3rd** *Effective*[1] *15% Effective*[2]	**Comments**
Str Juan de Fuca	**None**	43 (83)	-	-	-	Significant reduction shoreline oiling with mech response. Little difference in CAPS
	Mech	-	27 (91) 37 (71)	20 (52) 37 (71)	23 (82) 37 (71)	
	Disp	-	-	-	-	
	ISB	-	-	-	-	

[1]Mean shoreline impact with effective on-water mechanical spill response, as modeled. Mean + 2 standard deviations in parentheses. [2]Mean shoreline impact assuming 15% on-water mechanical spill response.

Table 31: Comparison of Mean Response Costs[1] by Response Capability/Method: Diesel Spills (Million Dollars)						
Location	**Response Type**	**No Response**	**Federal** *Effective*[2] *15% Effective*[3]	**State** *Effective*[2] *15% Effective*[3]	**3rd** *Effective*[2] *15% Effective*[3]	**Comments**[4]
Str Juan de Fuca	**None**	$31.6 ($34.3)	-	-	-	Increase in costs with mech response. No significant difference in CAPS
	Mech	-	$40.5 ($42.7) $36.7 ($39.8)	$42.1 ($44.3) $38.1 ($42.0)	$44.1 ($47.9) $39.4 ($34.2)	
	Disp	-	-	-	-	
	ISB	-	-	-	-	

[1]Mean response (Mean + 2 standard deviations) costs in million dollars (2003$). [2]Mean response costs with effective modeled mechanical response. [3]Mean response costs wiht 15% on-water mechanical spill response. [4]CAPS = response capabilities. NR = "no response" DISP = dispersant; mech = mechanical; ISB = *in-situ* burning.

Table 32: Comparison of Shoreline Oiling by Response Capability: Bunker Spills (1,000 m^2 oiled)						
Location	**Response Type**	**No Response**	**Federal** *Effective*[1] *15% Effective*[2]	**State** *Effective*[1] *15% Effective*[2]	**3rd** *Effective*[1] *15% Effective*[2]	**Comments**
Str Juan de Fuca	**None**	50 (73)	-	-	-	Significant reduction impact with mech and ISB response. Slight reduction in ISB over mech.
	Mech	-	14 (42) 43 (62)	15 (38) 43 (62)	11 (34) 43 (62)	
	Disp	-	-	-	-	
	ISB	-	-	4 (16) 43 (62)	-	
Columbia River West	**None**	154 (194)	-	-	-	Significant reduction impact with mech response. Slight reduction with CAPS
	Mech	-	57 (106) 131 (165)	54 (95) 131 (165)	49 (89) 131 (165)	
	Disp	-	-	-	-	
	ISB	-	-	-	-	
Columbia River East	**None**	65 (92)	-	-	-	Significant reduction impact with mech response. No difference with CAPS
	Mech	-	22 (46) 55 (78)	20 (45) 55 (78)	23 (52) 55 (78)	
	Disp	-	-	-	-	
	ISB	-	-	-	-	

[1]Mean shoreline impact with effective on-water mechanical spill response, as modeled. Mean + 2 standard deviations in parentheses. [2]Mean shoreline impact assuming 15% on-water mechanical spill response.

Table 33: Comparison of Mean Response Costs[1] by Response Capability: Bunker Spills (Million Dollars)						
Location	**Response Type**	**No Response**	**Federal** *Effective[2]* *15% Effective[3]*	**State** *Effective[2]* *15% Effective[3]*	**3rd** *Effective[2]* *15% Effective[3]*	**Comments[4]**
Str Juan de Fuca	**None**	$27.1 ($28.8)	-	-	-	No significant difference in costs between response methods or CAPS
	Mech	-	$30.6 ($34.9) $33.3 ($34.7)	$30.8 ($35.2) $33.6 ($35.0)	$30.3 ($33.9) $33.8 ($35.2)	
	Disp	-	-	-	-	
	ISB	-	-	$26.4 ($28.4) $31.6 ($33.0)	-	
Columbia River West	**None**	$53.8 ($58.2)	-	-	-	Significant reduction with mech response. No difference between CAPS
	Mech	-	$40.6 ($47.5) $55.7 ($58.7)	$40.5 ($49.1) $56.7 ($60.0)	$40.2 ($45.9) $57.1 ($60.3)	
	Disp	-	-	-	-	
	ISB	-	-	-	-	
Columbia River East	**None**	$29.9 ($33.5)	-	-	-	Slight reduction with mech response. No difference between CAPS
	Mech	-	$32.8 ($36.8) $35.9 ($38.9)	$34.4 ($35.9) $37.1 ($40.3)	$35.6 ($38.6) $37.5 ($40.7)	
	Disp	-	-	-	-	
	ISB	-	-	-	-	

[1]Mean response (Mean + 2 standard deviations) costs in million dollars (2003$). [2]Mean response costs with effective modeled mechanical response. [3]Mean response costs wiht 15% on-water mechanical spill response. [4]CAPS = response capabilities. NR = "no response" DISP = dispersant; mech = mechanical; ISB = *in-situ* burning.

Summary and Conclusions

- ***Response Cost Ranges:*** Estimated response costs based on SIMAP trajectory, fates, removal, and impacts modeling show that the response to a major oil spill in Washington state waters could vary from $30 million to about $140 million, depending on a number of factors, including oil type, location, effectiveness of on-water (offshore) response efforts, response methodology, and response capability. Response costs in this study include costs for salvage of the vessel, which is not always included in response cost estimates seen elsewhere. Removal of this amount changes the figures somewhat. In all cases with a known responsible party (as was the case in these modeling exercises), response costs are borne by the responsible party (vessel owner and/or operator) and their insurers.

- ***Difference in Response Costs for Crude Spills:*** There are significant reductions in response costs for San Juan Islands and Inners Straits crude oil spill scenarios with the use of on-water mechanical recovery. Dispersant use does not appear to appreciably reduce response costs or shoreline impacts for San Juan Islands scenarios, though there is some greater reduction in the Inner Straits. This is likely due to the limited area of dispersant application (at the outer edges of the spill slick) in the San Juan Islands area, as well as delays in application (see under Dispersant Effectiveness below). There

- ***Shoreline Impacts:*** Shoreline impacts are greatly reduced – potentially as much as 80% – when on-water (offshore) recovery efforts are timely and effective, particularly for crude and bunker spills. Diesel tends to evaporate and disperse more quickly, reducing the benefit of on-water recovery. Relative reductions in shoreline impacts are dependent on *timely and effective* on-water responses, by mechanical, dispersant, or *in-situ* burning means.

- ***Mechanical Effectiveness:*** Modeled mechanical effectiveness was assumed to be the equivalent of the effective daily response capability (EDRC) in the response capability tables. Mechanical effectiveness, as modeled, approached 50 to 90% in many scenarios. In actual historical responses and current practice, mechanical recovery effectiveness is rarely greater than 15% to perhaps 25%, except in sheltered areas or in areas directly around an already pre-boomed vessel loading or lightering in port..[1] Any inefficiencies or errors by response crews and officials (*e.g.*, in miscalculating the oil trajectory, failure to direct booming and on-water recovery operations from overhead helicopters or planes to maximize oil capture, deployment of defective or poorly-maintained equipment, delays in getting equipment on-site (due to greater distances, weather conditions, logistical problems), or weather events can all greatly reduce the effectiveness of on-water recovery operations.

- ***Dispersant Effectiveness:*** Delays in applying dispersant chemicals causes the oil to spread to the point of relative ineffectiveness in some cases. Reducing the time delay

[1] Reports of higher mechanical response efficiencies (*e.g*., DeCola, undated) are known by ERC to be based on misinformation and incorrect data (see Etkin 2004*c* memo to National Academy of Sciences, Committee on Understanding Oil Spill Dispersants: Efficacy and Effects)

in dispersant application, by making more planes, chemicals, and equipment available more quickly will likely increase the effectiveness of offshore dispersant application by giving the dispersants thicker and more consolidated oil to work on. Dispersants do not appear to reduce shoreline oiling for most scenarios. Reduced dispersant effectiveness is likely, in part, to be due to an artifact in the modeling that allowed for extremely high mechanical recovery rates to take precedence. By the time the planes had arrived, much mechanical recovery was already underway in highest efficiency. The San Juan Islands area does not have enough area far enough from shore and deep enough to allow for dispersant application except in the northern and southern portions, as shown in the map in Figure 7. Dispersant application may have distinct advantages in offshore spills off the Outer Coast when mechanical recovery equipment is difficult to deploy in a timely fashion.

- ***In-Situ Burn Effectiveness**: In-situ* burning does not appear to appreciably change the amount of shoreline oiling over mechanical response or dispersant-aided mechanical response for the Outer Coast and Strait of Juan de Fuca crude scenarios. This is likely explained by the extremely high rate of mechanical recovery inherent in the modeling. Lower, more realistic, mechanical recovery rates may increase the relative effectiveness of burning.

- ***Use of Response Costs in Cost-Benefit Analysis:*** The use of the response costs in this modeling work for the purposes of conducting cost-benefit analyses should include weighting of the response scenarios by oil type, vessel size and likely spill size (*e.g.*, based on studies of spill scenarios as in Etkin 2001*b*), as well as analyses of the actual likelihood of a spill given the amount of vessel traffic and navigational challenges of Washington waters. A fault-tree analysis could help in determining the probabilities of spills and could be coupled with information on oil spill sizes. The likely type of spill response, given response capability requirements, including preparedness for dispersant use, by the US Coast Guard, and local or regional guidelines also needs to be taken into account, inasmuch as the response type can influence costs. The likelihood of no-response or highly ineffective responses, given weather conditions, training and preparedness, and other factors, should be considered.

References

Alan A. Allen, Spiltec, Inc., Woodinville, WA. 2004. Personal communication. 21 January 2004.

Allen, A.A., and R.J. Ferek, 1993. Advantages and disadvantages of burning spilled oil. *Proceedings of the 1993 International Oil Spill Conference:* pp. 765-772.

American Petroleum Institute (API), National Oceanic and Atmospheric Administration (NOAA), US Coast Guard (USCG), and US Environmental Protection Agency (USEPA). 2001. *Characteristics of Response Strategies: A Guide for Spill Response Planning in Marine Environments*. Joint Publication of API, NOAA, USCG, and USEPA, June 2001, 80 pp.

Davis, B., D.S. Etkin, M. Landry, and K. Watts. 2004. Determination of oil persistence: A historical perspective. *Proceedings of the Fifth Biennial Freshwater Spills Symposium:* in press.

DeCola, E. undated. ***Review of Oil Spill Responses on Moderately-Sized Spills in US Waters from 1993 – 2000.*** Prepared for the Prince William Sound Regional Citizens Advisory Council (PWS RCAC). Nuka Research Planning Group, LLC, Seldovia, Alaska. 9 pp.

Etkin, D.S. 1995. *Case Study: The Morris J. Berman Oil Spill*, Cutter Information Corp., Arlington, MA, 135 pp.

Etkin, D.S. 1998*a*. Factors in the dispersant use decision-making process: An historical overview and look to the future. *Proc. 21st Arctic & Marine Oilspill Program Tech. Sem.*: pp. 281 – 304.

Etkin, D.S. 1998*b*. *Financial Costs of Oil Spills in the United States*, Cutter Information Corp., Arlington, MA, 346 pp.

Etkin, D.S. 1998*c*. *Financial Costs of Oil Spills Worldwide*, Cutter Information Corp., Arlington, MA, 368 pp.

Etkin, D.S. 1999*a*. Estimating cleanup costs for oil spills. *Proc. 1999 International Oil Spill Conf.*: pp. 35-39.

Etkin, D.S. 1999*b*. *Oil Spill Dispersants: From Technology to Policy*, Cutter Information Corp., Arlington, MA. 305 pp.

Etkin, D.S. 2000. Worldwide analysis of oil spill cleanup cost factors. *Proc. 23rd Arctic & Marine Oilspill Program Tech. Sem.*: pp. 161 – 174.

Etkin, D.S. 2001*a*. Analysis of oil spill trends in the US and worldwide. *Proc. 2001 International Oil Spill Conf.:* pp. 1,291 – 1,300.

Etkin, D.S. 2001*b*. *Analysis of Washington State Vessel and Facility Oil Discharge Scenarios For Contingency Planning Standards.* Prepared for Washington Department of Ecology, Spills Program, Olympia, Washington. Contract No. C0200096. 21 September 2001. 81 pp.

Etkin, D.S. 2001*c*. Comparative methodologies for estimating on-water response costs for marine oil spills. *Proc. 2001 International Oil Spill Conf.:* pp. 1,281 – 1,289.

Etkin, D.S. 2001*d*. Methodologies for estimating shoreline cleanup costs. *Proc. 24th Arctic & Marine Oilspill Program Tech. Sem.*: pp. 647 – 670.

Etkin, D.S. 2002. Analysis of past marine oil spill rates and trends for future contingency planning. *Proc. 25th Arctic & Marine Oilspill Program Tech. Sem.*: pp. 227 – 252.

Etkin, D.S. 2003*a*. Analysis of US oil spill trends to develop scenarios for contingency planning. *Proc. 2003 International Oil Spill Conf.:* pp. 47 – 61.

Etkin, D.S. 2003*b*. Estimation of shoreline response cost factors. *Proc. 2003 International Oil Spill Conf.:* pp. 1,243 – 1,253.

Etkin, D.S. 2004*a*. Modeling oil spill response and damage costs. *Proceedings of the Fifth Biennial Freshwater Spills Symposium:* in press.

Etkin, D.S. 2004*b*. Twenty-year trend analysis of oil spills in EPA jurisdiction. *Proceedings of the Fifth Biennial Freshwater Spills Symposium:* in press.

Etkin, D.S. 2004*c*. 4 June 2004 Memorandum to National Academy of Sciences Committee on Understanding Oil Spill Dispersants: Efficacy and Effects re: *Comments on Review of Oil Spill Responses on Moderately-Sized Spills in US Waters from 1993 – 2000*, report by Elise DeCola, Nuka Research Planning Group, for Prince William Sound Regional Citizens Advisory Council, as presented to National Academy of Sciences Committee on Understanding Oil Spill Dispersants: Efficacy and Effects on 18 May 2004.

Etkin, D.S. and P. Tebeau, P. 2003. Assessing progress and benefits of oil spill response technology development since Exxon Valdez. *Proc. 2003 International Oil Spill Conf.:* pp. 843 – 850.

Etkin, D.S., and J. Neel. 2001. Investing in spill prevention – Has it reduced vessel spills and accidents in Washington state? *Proc. 2001 International Oil Spill Conf.:* pp. 47 – 56.

Etkin, D.S., D. French McCay, J. Jennings, N. Whittier, S. Subbayya, W. Saunders, and C. Dalton. 2003. Financial implications of hypothetical San Francisco bay oil spill scenarios: Response, socioeconomic, and natural resource damage costs. *Proc. 2003 International Oil Spill Conf.:* pp. 1,317 –1,325.

Etkin, D.S., D. French-McCay, N.Whittier, S. Subbayya,, and J. Jennings 2002. Modeling of response, socioeconomic, and natural resource damage costs for hypothetical oil spill scenarios in San Francisco Bay. *Proc. 25th Arctic & Marine Oilspill Program Tech. Sem.*: pp. 1,075 – 1,102.

Fingas, M. 2001. *Basics of Oil Spill Cleanup, Second Edition,* Lewis Publishers, Washington, DC. 233 pp.

Fingas, M. and M. Punt. 2000. *In-situ Burning: A Cleanup Technique for Oil Spills on Water.* Emergencies Science Division, Environmental Technology Centre, Environment Canada, Ottawa, Ontario, Canada. 214 pp.

French Mc-Cay, D., J.J. Rowe, N. Whittier, S. Sankaranarayanan, D.S. Etkin. 2004. Estimation of potential impacts and natural resource damages of oil. *Journal of Hazardous Materials.* Vol. 107: pp. 11 – 25.

French-McCay, D., and J.R. Payne. 2001. Model of oil fate and water concentrations with and without application of dispersants. *Proceedings of the 24th Arctic and Marine Oilspill (AMOP) Technical Seminar*: pp.611 – 645.

French-McCay, D., N.Whittier, S. Subbayya, J. Jennings, and D.S. Etkin. 2002. Modeling fates and impacts for bio-economic analysis of hypothetical oil spill scenarios in San Francisco Bay. *Proc. 25th Arctic & Marine Oilspill Program Tech. Sem.*: pp. 1,051 – 1,074.

Michel, J., and M. Cotsapas, 1997. *Assessment of the Cleanup Costs Resulting From Platform Spills in the Gulf of Mexico Offshore of Apalachicola Bay, Florida*. Research Planning, Inc., Columbia, South Carolina, USA, 12 pp.

Michel, J., D. French-McCay, and D.S. Etkin. 2001. *Final Report: Assessment of the Potential Impacts of Oil Spills from the National Defense Reserve Fleet (NDRF).* Prepared for Maritime Administration, South Atlantic Region, Department of

Transportation, Norfolk, Virginia. Prepared by Research Planning, Inc., Applied Science Associates, and Environmental Research Consulting. October 2001. 75 pp.

Michel, J., D. French-McCay, and D.S. Etkin. 2002. *Assessment of the Potential NRDA and Cleanup Costs of Oil Spills from the National Defense Reserve Fleet.* Prepared for Maritime Administration, South Atlantic Region, Department of Transportation, Norfolk, Virginia. Prepared by Research Planning, Inc., Applied Science Associates, and Environmental Research Consulting. May 2002. 20 pp.

Moller, T., H.D. Parker, and J.A. Nichols, 1987. Comparative costs of oil spill cleanup techniques. *Proceedings of the 1987 International Oil Spill Conference:* 123-127.

Monahan, T.P., and A.W. Maki. 1991. The Exxon Valdez oil sill 1989 wildlife rescue and rehabilitation program. Proceedings of the 1991 International Oil Spill Conference: pp. 131 – 136.

National Oceanic and Atmospheric Administration. 1997. *Oil Spill Response & Planning: In Situ Burning.* National Oceanic and Atmospheric Administration, Office of Response and Restoration, Hazardous Materials Response Division, Seattle, Washington, USA.

National Oceanic and Atmospheric Administration, 1998. *Spill Tools: Dispersant Mission Planner.* National Oceanic and Atmospheric Administration, Office of Response and Restoration, Hazardous Materials Response Division, Seattle, Washington, USA.

Northwest Area Committee. 2003. *Northwest Area Contingency Plan 2003 (and Region 10 Regional Contingency Plan)*. Prepared by US Coast Guard 13th District, US Environmental Protection Agency Region 10 Regional Response Team, Marine Safety Office Puget Sound, Marine Safety Office Portland, Washington Department of Ecology, Idaho Bureau of Hazardous Materials, and Oregon Department of Environmental Quality. 1 February 2003.

Pond, R.G., D.V. Aurand, and J.A. Kraly, 2000. *Ecological Risk Assessment Principles Applied to Oil Spill Response Planning in the San Francisco Bay Area*. California Office of Spill Prevention and Response, California Department of Fish and Game, Sacramento, California, USA, 200 pp.

US Coast Guard Research & Development Center. 1999. *Past In-situ Burning Possibilities.* Report No. CG-D-17-99. US Coast Guard Research & Development Center, Groton, CT. 26 pp.

US Coast Guard, 1999. *Response Plan Equipment Caps Review*. Draft report. August 1999. US Coast Guard Commandant, Office of Response, Washington, DC.

US Coast Guard. 1996. Vessel Response Plans: Final Rule. *Federal Register* Vol. 61 (9): pp. 1,052 – 1,108. 12 January 1996.

US Coast Guard. 2002. Vessel and Facility Response Plans for Oil: 2003 Removal Equipment Requirements and Alternative Technology Revisions: Notice of Proposed Rulemaking. *Federal Register* Vol. 67 (198): pp. 63,331 – 63,452. 11 October 2002.

US Environmental Protection Agency. 2003. *Environmental Protection Agency National Contingency Plan Product Schedule.* US Environmental Protection Agency, Washington, DC. November 2003.